Intelligent recycling of (CFRP) rotor blades is still a challenge

Wolfram Axthelm,
Managing director strategy & politics
German Federal Association of Wind Energy

JEC Composites Magazine discussed with Wolfram Axthelm, Bundesverband WindEnergie e.V. (BWE), what is to be expected when the funding period of the German Renewable Energy Act (EEG) runs out in 2020. At this time, fewer and fewer wind energy systems are expected to be resold and reconstructed in other places due to increasing worldwide standards and the higher yields of more modern systems. Therefore, recycling is increasingly becoming an issue. In particular, the environmentally friendly recycling of rotor blades, mainly consisting of composite materials, particularly CFRP, is raising issues and is challenging researchers.

From 2021 onwards, the state subsidization of wind energy in Germany – granted through the German Renewable Energy Act (EEG) for the past 20 years – will lapse. Due to high leasing and insurance expenses and lower revenues, experts predict that further operation will be of no interest for operating companies. Therefore, it is likely that more than 2,000 outdated facilities will be dismantled every year. In Germany, around 29,800 wind turbines (28,500 are onshore wind turbines) are installed. Recycling is becoming an issue, since some rotor blade components are considered as hazardous waste. For most of the materials used, approved methods for an environmentally friendly recycling actually exist.

However, the recycling of rotor blades and the gondola material still raises some issues.

A typical wind power station consists of the foundation, the tower, the gondola with the gear box, generator and control electronics and, of course, the rotor blades. The materials used are concrete (63.5%) for the foundation and steel (32.1%), depending on the construction mode of the tower. Fibre-reinforced plastics, copper, aluminium, electronics and various fluids account for a relatively lower percentage of weight. For most of the parts, a recycling rate of 80 up to 90% can currently be achieved. The rotor blades constitute an exception since there are still pending issues when it comes to environmentally friendly and economically reasonable recycling [1].

Rotor blades are a conglomerate of synthetic resins and fibres (glass or carbon), the difficulty being to shred these composites. Up till now, rotor blades have often been dismantled and disposed in an adventurous manner [2].

According to Wolfram Axthelm, managing director of the Federal Association of Wind Energy (BWE), "*with 10,000 tons of dismantled rotor blades for the time being, the situation is not yet dramatic*". These figures will rise from 2021 onwards up to 40,000 tons per year in 2040. Whereas there was still an interesting market for discarded facilities in Eastern Europe, Russia or North Africa in the past, requirements and demands are increasing in these countries as well since the megawatt performance in modern plants was dramatically optimized in the meantime.

How Enercon is setting the course with regards to future prospects

interview

Alexander Hoffmann,
Key expert rotor blades
Enercon, WRD Wobben Research and Development GmbH

JEC Composites Magazine: With the new challenge as of 2021, the expiration of the EEG funding and the even greater need to use recyclable materials for the construction of future rotor blades, how is Enercon setting the course?

Alexander Hoffmann: The rotor blades used on wind energy converters are some of the most heavily loaded plastic components in the world. The durable dynamic strength requirements placed on the materials mean developers are faced with new challenges time and time again, owing especially to the sharply increasing cost pressure.

For this reason, we expect that glass fibre-reinforced plastics and carbon fibre-reinforced plastics (to a lesser extent) with an epoxy resin matrix will continue to be used more and more in our products in the years to come.

Current research findings indicate that it may be possible in the future to substitute the duroplastic epoxy resin with thermoplastics that are easier to recycle.

However, there are still a number of issues to be clarified here with regards to manufacturing technologies.

At the moment, we are focussing on developing cost-effective

and environmentally friendly ways to recycle glass and carbon fibre-reinforced plastics with a duroplastic epoxy resin matrix, and establishing them on the market.

Which type of composite material will be predominant in the future and what are the major recycling challenges for the moment? Could you share Enercon's position with us?

A.H.: In our rotor blade products, we mainly use glass fibre-reinforced and occasionally carbon fibre-reinforced plastics with an epoxy resin matrix, combined with PET foam and balsa wood.

When recycling the rotor blades, dismantling and removing the wind energy converters represents a huge cost factor. Environmentally friendly "pre-breaking down" processes are necessary at the dismantling sites in order to reduce transport costs. But they also involve a significant cost component.

Thermal and material utilisation in the cement industry is one of the methods currently available for recycling glass fibre-reinforced plastics.

However, complex and costly processes for breaking down and mixing them with other materials such as paper are required to provide cement kilns with suitable replacement fuel from disused rotor blades.

The glass fibres are melted in the combustion process and remain in the cement material produced as a silicate replacement.

A new recycling method we are now focussing on is ultra-high temperature hydrolysis (UHTH). In this method, the energy contained in the material is reclaimed in the form of clean syngas in a very eco-friendly way. This method is similar to classic pyrolysis. The difference is that considerably higher temperatures of at least 1100°C and a relatively high moisture content of approximately 30% are used here. Although the glass fibres recovered using UHTH technology are no longer of any interest to the wind energy industry, detailed analyses show that these fibres are suitable for use as a raw material in the hollow glass industry.

The clear advantage compared to the procedure used in the cement industry is that the preceding breaking-down process is much simpler and therefore more cost-effective.

Where recycling of carbon fibre-reinforced plastics is concerned, the recycling industry is currently focussing on the recovery of carbon fibres.

This approach is very positive from an energy point of view as a lot of energy is needed to manufacture the fibres. In this process, the epoxy resin is heated off in pyrolysis furnaces at temperatures from around 600 to 800°C. The reclaimed fibres are used to make products such as non-woven mats, which can be used in the automotive industry, for example.

However, there is one key drawback. As in the paper industry, the reclaimed fibres get smaller with every recycling step, due to the necessary pre-disintegration. This means there are only a small number of useful technical applications available for carbon fibres that have been reclaimed multiple times. In addition, breaking down carbon fibre-reinforced plastics can produce respirable dust that is harmful to health and the environment.

Another problem crops up when reclaiming carbon fibres from the wind energy sector.

The carbon fibres are always "contaminated" with glass fibres, making further processing more difficult and therefore economically unattractive.

The classic method of burning carbon fibre-reinforced plastics in conventional waste-to-energy plants does not represent an environmentally sound solution, either. Furthermore, the electrical conductivity of the fibres means they can cause short circuits or fires in downstream filter systems if they are not completely combusted.

In the course of our internal research project, we established that UHTH technology is a suitable candidate for thermal recycling and recovering energy from carbon fibre-reinforced plastics, and thus prevents the spread of environmentally hazardous substances.

What is your plea to wind energy suppliers to meet future requirements?

A.H.: In our opinion, the use of carbon fibres should be avoided in the wind energy industry wherever possible. At the same time, the development of electrically non-conductive high-performance fibre materials to be used for light construction in the wind energy branch should be forced. In view of the increasing amount of fibre-reinforced composites that has to be disposed of, it is up to the industry as a whole to develop sustainable and eco-friendly strategies and seek to set up partnerships where appropriate.

Neocomp recycles glass fibre-reinforced plastics from disused rotor blades

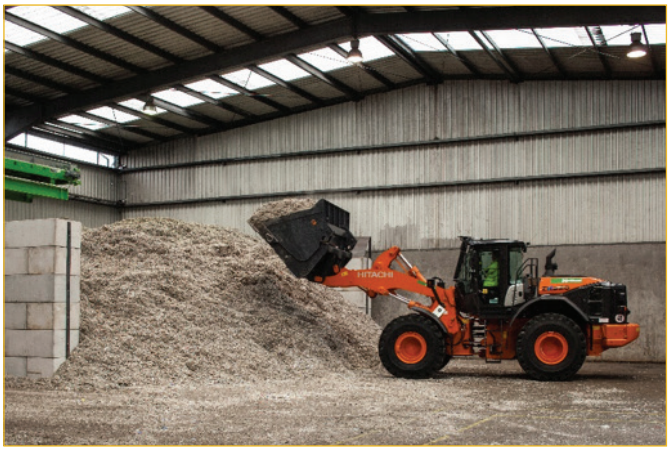
Dipl.-Ing. Hans-Dieter Wilcken,
Managing director
Neocomp GmbH & Co.KG and
Nehlsen GmbH & Co. KG

Bremen-based specialist of glass fibre-reinforced plastics recycling, Neocomp, a subsidiary of Nehlsen GmbH, won the Green-Tech Award 2017. Glass fibre-reinforced plastics represent the lion's share when talking about recycling of rotor blades.

Neocomp's managing director Hans-Dieter Wilcken remains sceptical about the increasing use of carbon fibres in different industry sectors like construction, boatbuilding, automotive and others, since the risks of dismantled composites are not yet fully explored. His plea to the producers of high-tech materials: "*Before new materials are going to industrial manufacturing in high quantities, all the impacts of an environmentally friendly recycling should be investigated*". He refers to the risk of producing so-called "respirable fibres" that may occur when carbon-reinforced composites are not professionally dismantled.

As he points out, uncontrolled decomposition through fire or other serious accidents could raise a "modern asbestosis" problem.

Fig. 1: Shredded rotor blades ©Nehlsen GmbH & Co.Kg



Shredded material for use in a cement plant ©Nehlsen GmbH & Co.KG

Web-based composites as a cost-efficient solution for carbon fibre recycling

Among the 16 textile research institutes in Germany, there is one specialized in the processing of technical fibres, particularly recycled carbon fibres, into web-based composites. ITA Augsburg, an affiliated institute of the University of Augsburg, located in the heart of the Augsburg innovation park (70 acres with optimum infrastructure), is applying textile research know-how from RWTH Aachen in the Augsburg research area, a dynamic technology and industry hub in Bavaria.

Univ.-Prof. Dr.-Ing. Stefan Schlichter,
Managing director
ITA (Institut für Textiltechnik Augsburg gemeinnützige GmbH), University of Augsburg

Stefan Schlichter, managing director ITA, says: *"We built up a rapidly growing niche in manufacturing web-based composites, primarily with thermoplastic matrices, and the processing of recycled composite fibre materials for new products".*

In the framework of the COSIMO project (composites for sustainable mobility), ITA is developing thermoplastic composites for mass production in two consortiums for aerospace and automotive applications. *"The availability of recycled carbon fibres has been ensured, but mass production know-how is still an issue. We are quite confident to provide the solution for series production by 2022."* □

More information:
www.wind-energie.de
www.ita-augsburg.de

References

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[2] Carsten Dierig/Daniel,Wetzel, article in DIE WELT, 17.02.2018 "Wenn das Windrad zum Sondermüll wird"