Composites in Wind Energy

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Abstract

The purpose of the present paper is to highlight the importance of using composite materials in the wind energy industry. As alternative renewable energy becomes a growing problem worldwide, investments in technologies such as solar and wind energy are growing significantly. Wind energy is a key source of renewable energy that produces electricity with very little greenhouse gas production. It is based on very high capacity wind turbines, which must be powerful and efficient. This means longer and lighter blades that are still stiff enough to withstand strong wind conditions. Carbon and glass fibre casting technology enables the production of long, light and powerful wind turbine blades, enabling a higher degree of efficiency in what has become a stable worldwide energy supply framework. The future use of these technologies will allow the development of higher capacity wind turbines, leading to a higher degree of adoption of wind power generation worldwide.

Key words: composite materials, wind energy, wind turbine, blades, reliability, manufacturing
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1. Introduction

Wind energy consists of obtaining electricity with the help of wind intensity, by using wind turbines that capture the energy that will later be transformed into electricity.

Due to ecological considerations and those regarding the growing demand for electricity, efficiency of production costs, as well as the need to supply electricity in locations where it is not possible to supply from the local distribution network, the development of alternative energy sources has made significant progress in recent years.

The wind energy industry is much less expensive and more sustainable in terms of protecting natural resources than traditional methods of obtaining energy. Furthermore, with the help of wind energy, even isolated areas can be supplied with electricity. In order to catch a larger amount of wind energy and for a higher efficiency, wind turbines are organized in wind farms, i.e. several wind turbines located in one area. Given this reason, rural areas are preferred, with smaller and fewer buildings. However, there is the advantage that the land surrounding the turbines is not affected by the operation of the turbines so it can be used without too many complications for agriculture or as pasture for animals.

But wind energy is not a new concept. In its primitive form, the power of the wind has been exploited since antiquity. In this sense we refer to the ships that sailed on Nill, in the 4th century BC. Or the first windmill built in the 7th century in ancient Persia to grind wheat.

Currently the main fuel, which is the basis of electricity generation, is oil, a fuel that according to data provided by the International Energy Agency will be depleted in about 40 years, gas in about 60 years and coal resources in about 200 years. Thus, the development and implementation of energy generation solutions using other natural resources, but using inexhaustible resources became more and more acute: tidal force, wind force, solar energy, etc.

Wind energy, renewable energy, is the transformation of the mechanical force of the wind, with specific installations for obtaining electricity. The wind is formed due to differences in temperature and atmospheric pressure between two geographical areas. Thus, since the earth's surface is spherical, the temperature and pressure are not evenly distributed; the wind intensity differs from one region to

another. Two aspects are especially important when you want to install a wind farm to generate wind energy: direction and speed. But these parameters vary in time and space.

In the following chapters we will present the importance of using composite materials in wind energy.

2. Theoretical background

The specialized literature in the field of composite materials is very extensive. The same can be said for the wind energy industry.

Composite materials have always existed in nature. The best known example is bone which is made from hydroxyapatite which is a hard material and collagen, a protein and a soft and elastic material at the same time. Another well-known example in nature is wood, made of long cellulose fibers that are polymers and a very weak substance called lignin. Composite materials have been used since ancient times even though the notion of composite material was not known at the time.

The extraordinary progress of technology allows us, nowadays, to be able to manufacture parts for many fields that can be both very large and very light, very thin but very rigid and, in addition, very resistant to various natural factors such as wind, rain, frost, extremely high temperature and more. It is known that the composite materials are new materials obtained from two or more materials. The composite materials obtained have very important and very useful properties that the constituent materials, taken separately, do not have. - Mishnaevsky, L., Composite Materials in Wind Energy Technology, Encyclopedia of Life Support Systems.

The need to produce energy from other sources also arose not only to reduce costs and protect natural resources, but also from the desire to bring electricity in hard to reach areas. Wind turbines have been produced to capture as much wind energy as possible. Wind turbines reach a height of over sixty to one hundred meters. It is even expected that the tallest wind turbine will be two hundred and forty two meters high. At the highest point of the turbine is the rotor. The rotor blades are the one that capture the wind energy. The blades must be very large and very rigid to be most effective. At the same time, it is very important that their weight is very low. Traditional materials that are rigid, if very large, are very heavy. In addition it must withstand all natural factors, considering that it operates outside. Last but not list it is desirable that their life span be long. Due to research and technological progress there are materials with such properties. Composite materials as fiberglass and carbon fibre are composite materials that meet all of the conditions listed above. - Mishnaevsky, L., Branner, K., Nørgaard Petersen, H., Beauson, J., McGugan, M., and Sørensen, B.F., 2017, Materials for Wind Turbine Blades: An Overview, US National Library of Medicine National Institutes of Health.

The objective of the present paper is to underline the importance of the use of composite materials in wind energy industry. - Marsh, G., 2014, Greater role for composites in wind energy, Elsevier, pp.20-24.

3. Research methodology

In order to write this paper, a study of the specialized literature and a research of the various parameters involved in the wind energy industry were conducted. Thus, official information and data are provided, according to the specialized studies performed, in order to show the enormous importance of composite materials in the wind energy industry; also, the economic and financial impact and even the influence in sustainable development can be observed.

In this article is presented a list of advantages of using composite materials in wind energy, like the fact that they are very environmentally friendly and there is no waste at the transformation of wind power into energy. Also the costs are reduced compared to the costs of the traditional method.

At the same time, a list of disadvantages is discussed. The biggest disadvantage is the variation of the wind intensity and the duration of the wind intensity. There is also a visual disadvantage, unfortunately. A solution to this problem is to set up offshore wind farms but higher installation and maintenance costs are at stake here.

Than the main criteria for setting up a wind farm is analyzed. First of all, the geographical position is important, but other factors must also be taken into account.

The equipment and the element of a wind turbine are described.

Given the way in which wind energy is captured to be transformed into electricity, analyzing the existing data and information, this article presents the extraordinary role that composite materials have in the wind energy industry.

4. Findings

The advantages of using wind energy:

- One hundred percent environmentally friendly source with zero emissions of greenhouse gases and substances harmful to the environment: the reason - the transformation of wind power into energy does not require combustion, as is the case with the conversion of fossil fuel power into electricity.
- Zero waste resulting from the transformation of wind power into electricity.
- Reduced costs for electricity production: in addition to the production costs, the costs of operation, use and maintenance of the facilities are minimal compared to the costs involved in the production of energy from fossil fuels.
- It does not require radical transformations of the environment adjacent to the operating space: the immediately surrounding area can be exploited for agricultural purposes without danger of contamination or disturbance of turbine operation.

The disadvantages of using wind energy:

Indeed, there is a downside to the medal, i.e. the disadvantages, but they are strictly related to the natural conditions. It is about: the variability in time and space of the wind intensity; unpleasant appearance, due to the installation of wind farms. To transform the mechanical power of the wind into electricity, wind farms are used, i.e. several wind turbines installed and connected to the National Energy System. If the maximum wind speed is exceeded, there is a risk of damaging the turbine blades. The wind turbine is an installation that transforms mechanical energy into electrical energy (wind energy). Depending on the needs, the turbines can be individual, with domestic use and without being connected to the distribution network, or grouped in the form of wind farms.

In general, wind turbines are not installed individually, but in wind farms connected to a distribution network. There is the possibility of installing offshore wind farms to avoid the unpleasant aspect. Although the costs would be much higher in all respects, much more offshore wind farms are expected to operate in the future than onshore ones.

The main criteria for the location of wind farms:

- Geographical position, relief and altitude.
- Wind intensity, direction and constant (regularity).
- Economic criteria: the price of the site, i.e. the land.
- Visual impact compared to nearby buildings.
- Distance from the distribution network.

Wind turbine equipment:

- An active system (hydra): ensures the maximization of the use of wind power by changing the angle of incidence of the blades, as well as for the protection of the system in case the wind power exceeds the nominal average value. Thus, if the average nominal value exceeds a threshold that can cause damage to the installations, the blades automatically switch to flag mode.
- Passive system (aerodynamic): in the case of this system the turbine blades are fixed in relation to the turbine hub. Thus, when the critical speed is reached, the blades are gradually unlocked.
- Mixed (active stall): this type of system is equipped with a mechanical brake, which locks the blades in case the wind speed exceeds the critical value.

The elements that make up a wind turbine:

- Blades: their design is essential in the development and production of wind energy. Blades or energy caps are made of a mixture of fiberglass and composite materials. They capture wind energy and transfer it to the rotor, which converts it into wind energy. The diameter of the blades

and their length depend on the installed power of the installation. The most efficient turbines are equipped with 3 blades, which, unlike single or double blades, reduce the vibration, noise and overload of the rotor.
- The platform or housing protects the generator from the inside.
- Pillar of support and resistance of the assembly.
- The foundation that ensures the mechanical resistance of the installation.

In view of the above it is clear that the materials from which the rotor blades are made are of the utmost importance. They must be simultaneously very rigid, very large, very light and very easy to maintain. The rotor blades must also be reliable. The operating period must be long but the production process must not be overly complex or expensive.

The biggest challenge of the moment is probably stopping for a longer period of time, with thinner turbine blades hitting the towers when they are deflected by the wind load. Rigid composite materials are needed, which must be even lighter.

The carbon fiber is a composite more than three times stronger than the glass and even more rigid than the glass. The carbon fiber is a composite which can be used for obtaining longer blades while maintaining the necessary rigidity. The lighter blades also have the advantage of lighter loads at the base.

But at list for now, carbon fiber is not the solution at a large scale, primarily because of the very high costs. Carbon fiber costs twenty times more than fiberglass, or even more. Another important factor is how well the manufacturing process that the manufacturer uses with carbon fiber fits.

Also, another very important aspect is recycling. It was pointed out earlier that composite materials used in wind energy also influence sustainable development. But, in sustainable development, the complete circuit of a material is taken into account, from its production to its decommissioning and its effective disposal. Probably the biggest disadvantage of wind turbine rotor blades is that they are very difficult to recycle. The rotor blades are replaced due to malfunctions or for operational reasons in order to be replaced with much larger blades that are much more efficient. One good thing is that old, non-recyclable wind turbine blades are being revived as bridges in Ireland. More exactly, the decommissioned wind turbine blades are now being used for bridge construction in Ireland, as an innovative solution to this recycling problem. Due to the high hardness of the material the replacement of the steel in light constructions such as pedestrian bridges with rotor blades was considered. A similar option was adopted by the British high-speed rail constructor, Skanska Costain Strabag. The company worked with the National
Center for Composites to replace steel with retracted turbine blades. In this way, wind turbine blades become an important element in the construction industry. The focus is also on the fiberglass. There is a method to recover fiber. More specifically, a team of researchers at Strathclyde University in Glasgow has discovered a system to recycle certain compounds used in wind turbine blades, which were previously impossible to recycle, which is why thousands of obsolete blades were buried annually, write CNBC and Electrek.co. The university had developed a process of recovery under the influence of thermal effect and treatment of the fiberglass from polymeric composites found in wind turbines, in order to obtain almost perfect quality glass fiber. This composite used in wind turbine blades is considered a difficult material to recycle and usually goes straight to the landfill. If implemented globally, it is estimated that the technology will meet almost half of the global demand for fiberglass.

5. Conclusions

In conclusion, the materials from which wind turbine blades are made evolve shoulder to shoulder with the manufacturing process: a higher efficiency is useless if it involves excessive effort and additional manufacturing costs. As installations become larger and rotors grow in size to match, the materials from which wind turbine blades are made must keep pace with various aspects, production conditions and new materials. Nowadays, rotor blades need to be as wide and rigid as possible in order to collect as much wind energy as possible. At the same time, the blades should be lighter in relation with their size and their maintenance should not be too complex.

Recycling is also becoming more and more important, an aspect that the current materials for wind turbine blades are struggling with, but studies and research offer more and more opportunities to reduce the negative effects.

The conclusion is always drawn to the cost per kWh. Any excess power produced must be determined in relation to the production, installation and maintenance process, and any material that does not help reduce the cost of the life of a turbine must be disposed of mercilessly.

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