A Novel Method to Reduce Radar Cross Section Area of Rotating Wind Turbine Blades by Carbon Nanotube Cellulose Nanocomposite Treated Glass Fiber

Jari Jekkonen*, Veijo Kangas**, Merja Paakkari#
*Morphona Ltd., **Winden Ltd., #Hafmex Oy

Abstract

The reduction of Radar Cross Section (RCS) is an important aspect when planning a modern wind power plant. In European Union (EU) more than 20 GW of wind power plant building permits are rejected because they interfere civil and military radars. The estimated value in 2011 was more than 30 billion €. [1]

A promising method to reduce the Doppler effect of rotating wind turbine blades was developed. A new radar absorbing material (RAM) was developed by impregnating carbon nanotube cellulose nanocomposite CNTCNC glass fiber laminate directly to glass reinforced plastic (GRP). The developed CNTCNC treated GRP will allow building wind turbines to the restricted areas to harvest sustainable wind energy.

A glass fiber laminate structure was developed and measured on a standard radar reflector to demonstrate the effectiveness of the CNTCNC to reduce radar reflection. Results show significant RCS reduction, more than 10 dB above the frequencies of 18 GHz.

This solution could ensure bigger wind turbine constructions with bigger energy capacity which would enhance cheaper sustainable energy production.

Objectives

Scope of the project was to find a method to integrate RAM to existing blade structures without the need to change the manufacturing processes. Cost of the selected method was also a key to decide the RAM mitigation, Figure 1.

The earlier study of the EMI shielding effects of CNTCNC already showed that the material would be capable to absorb electromagnetic radiation [2].

The direct impregnation of to glass fiber material was a primary target to enable the use of the standard GRP laminating processes to manufacture wind turbine blades.

Methods

A standard woven glass fiber fabric was used as a carrier for the CNTCNC dispersion. The CNTCNC treated glass fiber fabric was laminated between two clean glass fiber fabrics to obtain a RAM sample, Figure 2.

A reference and eight RAM samples, aluminum reflectors, were prepared to assess the effect of different recipes of the CNTCNC dispersions. Eight radar reflectors were coated by the RAM samples and the RCS reduction was measured in an anechoic chamber.

Material sample attenuations were measured in radio frequency (RF) anechoic chamber. Principle of the measurement is shown in Figure 3.

Results

The results show that the electromagnetic reflection was reduced by 10 dB in the frequencies below 15 GHz and more than 15 dB above 15 GHz up to 18 GHz. Maximum of 20 dB reduction was achieved in frequencies above 18 GHz of the best RAM samples.

Conclusions

A promising method to reduce the Doppler Effect of rotating wind turbine blades was developed. The study indicates that the reflection of the electromagnetic wave from the wind turbine blade can be mitigated by impregnating the CNTCNC to the glass fiber laminate directly. The results show that it is possible to achieve a significant reduction of RCS of metal structures by applying the developed CNTCNC based absorbing glass fiber stack on top of the metal layer. The results also suggest that the CNTCNC treated wind turbine blades will reduce the size of the ghost images in radar systems and thus ensure the radar to see the objects behind the wind power plant better. That will open new possibilities to build higher wind turbine towers and build wind mills to rejected areas to harvest more sustainable wind power.

References