Novel Non-Contact Deformation Health Monitoring of Towers and Rotating Composite Based Wind Turbine Blades Using Interferometric Ground Based Radar

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SUMMARY

Wind turbine blades type certification is done on one or two blades of the given design, to address two main fatigue failure types: cross-sectional shear distortion and non-linear out of plane deformation of load carrying cap laminate. Thus, for every 1,000 blades made only 2 are tested comprehensively due to the laborious and time-consuming deformation monitoring and testing processes during manufacture and operation. These contact type deformation monitoring process hinder the further development of composite blades and actual field monitoring of rotating wind turbines blades.

The main objective of this original research paper is to demonstrate the novelty in using a quasi-monostatic ground-based radar (GBR) as a non-destructive, non-contact deformation monitoring sensor to determine static and dynamic non-linear out of plane deformation and natural frequencies of blade and tower of a 56-meter long rotating wind turbine blades. By determining these parameters, all blades can be monitored in less than 2 minutes during manufacture and operation and results fed back into design.

The results benchmarked at average wind speeds of 6m/s indicate that the GBR can determine both the first mode (1P) natural frequency for the flap wise and edge wise blade deflections. Specifically, it gave 0.45 ±5\％ Hz and 0.88 ±5\％ Hz respectively, as compared to the design frequencies of 0.45±5％ Hz and 0.87±5\％ respectively. For the tower, a natural frequency of 0.2±5\％Hz was acquired as compared to the design frequency of 0.28±5\％ Hz. The nacelle deflection in the forward and backward oscillations ranged between 0.18 to 0.33m, while the wind turbine blade tips vibrated deflected between 4.28 and 5.85 m, well within the maximum design deflection of

10.15m.

The work provides 3 significant contributions: (1) in design of wind turbines blades and towers, the GBR can be used as fast, accurate and portable sensor in assessing blade modes using various composites materials in static and dynamic mode, (2) in the wind parks, it can be used to system health monitoring of wind turbines, providing valuable smart feedback on the blade and tower performance as well as acting as an early warning system, and lastly (3), in the application of wind turbines integrated in buildings and smart cities, a monitoring system that can oversea and supervise deflections and natural vibration frequencies of both buildings and wind turbines atop of them, provides a hereto before unheralded possibilities.