FATIGUE DAMAGE ANALYSIS OF GFRP & CFRP LAMINATES UNDER VARIABLE AMPLITUDE LOADS

Keywords: Fiber Reinforced Composites (FRC), Fatigue, Acoustic Emission (AE), Goodman diagram

Fiber Reinforced Plastic (FRP) composite materials are widely employed in dynamic load carrying primary structures, such as, wind turbine rotor blades and aircraft wings that are subjected to highly variable amplitude fatigue loads (Fig 1). The number of fatigue cycles these structures undergo in their life time vary between 60-80million cycles. The objective of this research work is to estimate the minimum damage initiation threshold strain limits for Glass Fiber Reinforced Plastic (GFRP) and Carbon Fiber Reinforced Plastic (CFRP) composites under Tension-Tension (T-T) and Tension-Compression (T-C) and Compression-Compression (C-C) constant amplitude fatigue loads. The aforementioned experiments will be accomplished at the representative load ratio's (R values) of 0.1,-1and 10 using the Acoustic Emission (AE) test set-up. In reality, these composite structures are subjected to a highly variable amplitude fatigue loads. However, it is not practical to test the material at different stress-strain amplitudes. Hence, using the above specified test load ratios, Goodman diagram will be constructed to account intermediate load ratio's that are occurring in the practical structure.

Following the minimum damage initiation thresholds obtained from the AE test set-up using different materials (UD, Biax and tri axial laminates), failure envelopes will be plotted for these materials with the aim of obtaining maximum sustainable strain limit under multi axial load state, without damage initiation. Using this method one can eliminate the errors associated with the Minor damage sum in the Constant Life Diagram (CLD) methodology to estimate the fatigue damage of these structures. Moreover, the obtained design allowable strain limits for these materials are well validated based on the physical damage behaviour rather than the phenomenological observation of the materials.

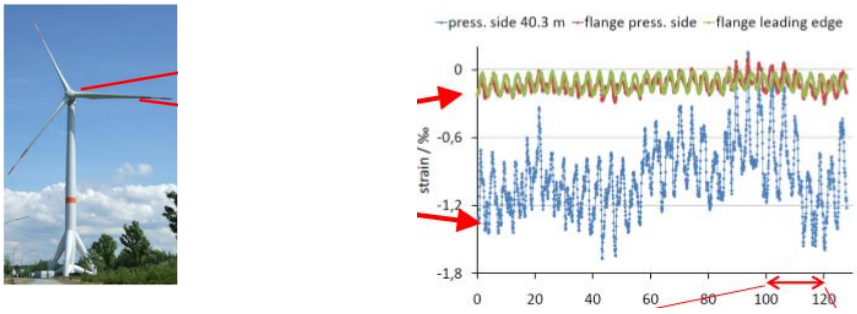

Fig1.Variable amplitude fatigue load spectrum of a wind turbine rotor blade [1].

Reference:

[1]. Trappe. V et.al, Effective composite testing for wind turbine blades – from specimen size to component scale. 4th International Conference Advances in Rotor Blades for Wind Turbines, Bremen, Germany, 24-26 February 2015.