Assess Influence of Stitch patterns and Sizing on Infusion speed of Glass Fabric Composites

Apply!
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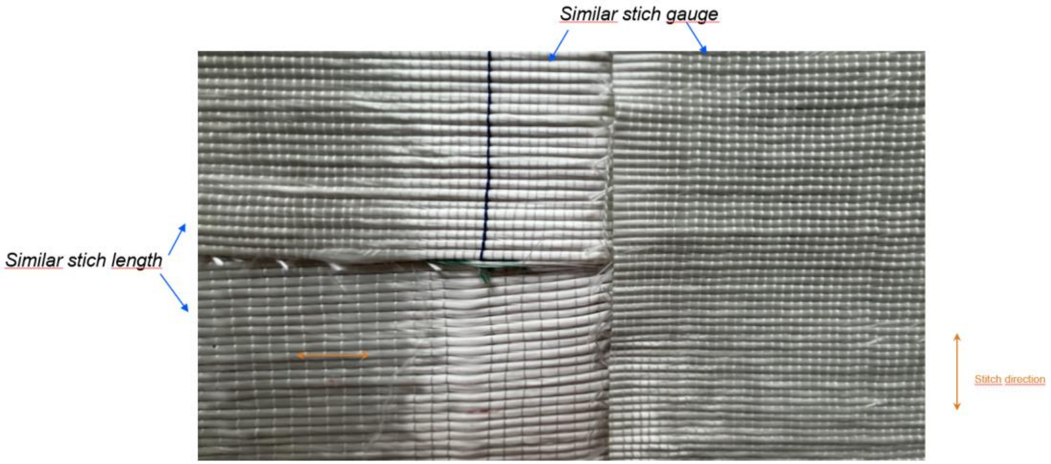
Background

Dry fibre composite panel infusion speed is a primary factor in the build time of large-scale composite structures.

There are necessary compromises to ensure that the infusion speed is "balanced" – ensure that the entire structure is fully infused (or "wetted out"), without leaving any dry (non-infused) areas.

There are also competing requirements in the infusion of a composite panel, such as desired Fibre Volume Fraction and Cured panel thickness.

Key parameters for study in this project would be assessment of the ply roving stitch patterns: including (warp/weft direction), stitch length and gauge, stitch yarn type and diameter, roving fibre sizing



Scope

Prepare glass/epoxy composite panels, infuse and cure as part of the tests.

Understand the effect the key parameters identified above influence infusion speed (across and through the ply layup) and characterise their impact on wet-out time. Assess the degree of voidage/dryness in the cured panels.

Compare the infusion speed with the cured panel fibre volume fraction and panel thickness for different glass/epoxy panel ply layups.

Develop a simple design model to give a first order prediction of the influence these properties on the infusion time, and cured panel thickness.

Keywords: Composites, Glass/Epoxy, Resin infusion, Cure, Process time, Fibre Volume Fraction

Degree of cure model assessment

Apply!
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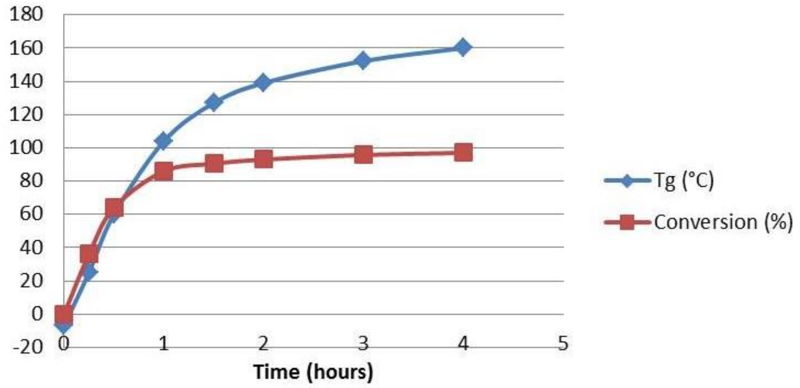
Background

Controlling the time and temperature of an epoxy during the cure a critical to ensure a full cure and to minimise the damage due to any heating from the energy released during the exothermic reaction. The degree of cure of an epoxy system is a requirement for the safe manufacture of wind turbine blades. The epoxy must be above 95% cured before any further cutting/grinding can be done.

Modelling the cure of an epoxy system with different temperature profiles is a complex task that requires an extensive data set. The intention of this work is to reduce the dataset needed by comparing different models and methods for determining the degree of cure of epoxy system.



Scope

1. The initial focus of this work is to establish a dataset for assessing the degree of cure of different epoxies and developing a model to predict the degree of cure for different epoxy systems that undergo different temperature cure profiles.
2. Continuation of this would then be to assess different models and determine the minimum data that is needed to construct a robust model for predicting the degree of cure of an epoxy system.
3. The goal is to arrive at a predictive model that can give an optimum cure profile target an internal temperature range and reduce the time taken to cure the epoxy.

Keywords: Epoxy, modelling, curing

Improve simulation analysis and requirement drapeability on Glass Fabrics

Apply!
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Background

Drapeabillity is a complex material property that heavily impacts the manufacture of compostite parts. It is used on both design and process simulations.

Nowadays, glass fabric plies handling behavior is analyzed primarily during material qualification by mimicking a serial production blade(s) manufacturing. However, it is a subjective evaluation (handling, visual inspection; time of layup) which depends on the operator and the factory where the test is performed.

Source: Glass Fabric Properties and Selection Criteria – GIVIDI FABRICS (gividi-fabrics.com) accessed on 12/08/2024

Scope

1. Understand what parameters influence drapeability and characterize their impact with the ply stacks.
2. Develop a characterization method to test this property.
3. Verify which requirement would be the most reliable to test in qualification and/or serial production.

Keywords: Drapeability; quality, simulation, testing, production, trial, stack, ply, composite, blades

Advancing Floating Offshore Wind Turbine Technology: Loads and Control Improvements for Product Optimization

Apply!
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Background

The full potential of wind energy exploration hinges on investing in floating offshore generator platforms. However, this solution is still in its early development stages, facing significant challenges in structural integrity, power performance, and lifecycle optimization. To address these issues, both experimental and numerical tests/simulations are essential for engineering reliable and financially feasible floating offshore wind turbine generators (FOWT). The main challenges can be divided into two intertwined knowledge areas: Loads and Control (LaC). The first area focuses on accurately estimating FOWT's structural response and stability under severe wind conditions. The second aims to optimize annual energy production (AEP) by mitigating load exceedances and stabilizing the FOWT structure. This thesis is intended to advance state-of-the-art topics in LaC.

Scope

The thesis will target one or more of the following technological challenges:

- Improving the accuracy of FOWT aero-hydro-servo-elastic simulation methodologies (e.g., via OpenFAST)
- FOWT system identification for design optimization (e.g., estimation of hydrodynamic and modal properties)
- Lifecycle optimization strategies for reducing fatigue damage to improve AEP and/or extend lifetime
- Data-driven optimization of load estimation and/or automatic control strategies (e.g., linking Vestas fleet data to AI frameworks)
- Design of novel automatic controller features for FOWT, focusing on power performance optimization and/or structural stability/integrity

Keywords: Wind energy; Offshore; Floating; Loads; Control; Artificial Intelligence; Structural Dynamics; Aeroelasticity

Influence of hydrodynamic damping on floating wind turbines

Apply!
Contact person: Rui Couto
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Background

Exploring the offshore wind energy available in a deep sea, as it is the case of Portugal, requires the use of floating platforms. The implementation of this solution is still in a very preliminary stage. Therefore, required developments demand both experimental work and numerical simulations to better understand the driving factors for fatigue consumption on the main structural elements of a wind turbine.

The fatigue damage of onshore wind turbines' towers is significantly impacted by the wind conditions and the implemented control algorithms. For floating offshore wind turbines (FOWT), these aspects are still expected to be of the greatest importance. However, sea state conditions may also play a relevant role. Natural frequencies related to the tower-foundation assembly in floating wind systems are higher in comparison to a tower in fixed-bottom wind turbines due to the particular free-free boundary condition. This frequency is associated to a coupled mode between tower and foundation, whose value can impact significantly the fatigue of such assembly.

While the aerodynamic damping may dominate, the hydrodynamic damping will also help to reduce this loading and has not been widely experimentally validated for structures of this size and frequency range.

Scope

It is therefore suggested to test a scaled model of a floating platform together with a tower and mass representing the RNA in order to measure the hydrodynamic damping of this coupled mode, comparing against the predicted data by state-of-art tools used in the floating wind turbine industry.

For investigations related to presented topic, it is intended to use existing models of a 15MW floating wind turbine developed in an open-source software developed by NREL (OpenFAST). This model might be adapted to include particular features of the VESTAS® models to be explored. The student will have the opportunity to contact with advanced numerical models of wind turbines being directly engaged with the VESTAS® design team at Porto.

The numerical analysis to be performed in this context certainly brings notable developments in the area, understanding experimental results being collected at a floating wind turbine which is crucial for the design of future wind turbine models better adapted to the floating environment.

Keywords: Wind energy; Offshore; Floating; Modal Properties; Hydrodynamics;

LiDAR Assisted Wind Turbine Control

Apply!
Contact person: Micael Coelho
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Background

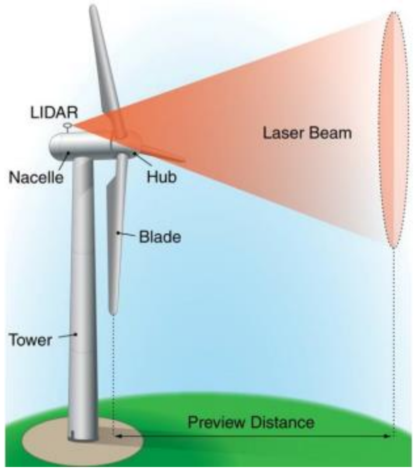
Wind turbines play a major role in solving climate crisis by being able to provide clean electricity. In addition to this, wind turbines are cheap and competitive sources of electricity, and hence, the number of installed wind turbines is expected to increase significantly over the years. Thus, it is important to ensure that each turbine is as efficient as possible.

Wind turbine controllers focus on maximizing the energy production and minimizing structural loads in order to reduce the levelized cost of energy (LCOE) and increase expected lifetime. Part of the challenge in optimizing the energy harvest from the wind derives from its turbulent nature and other phenomena such as wind shear. The wind speed used by the controller is either measured by an anemometer or estimated from rotor speed and power. An anemometer, can only measure wind speed and direction at a single point in space where the device is deployed and, thus, insufficient to observe the effective wind speed affecting the entire rotor. The wind speed estimation is filtered through the inertia of the rotor and reacts relatively slow. Consequently, traditional wind turbine controllers rely in feedback methods that react to the wind disturbances after they have affected the turbine.

Advances in LiDAR technology enables upwind measurements of wind speed, i.e. providing a preview of the wind field hitting the rotor. However, as the turbulence evolves, the LiDAR measurement is not an accurate prediction of exactly what hits the turbine. But it opens the door for enhanced control architectures that can take advantage of anticipated disturbances in wind speed.

Scope

Explore the potential of LiDAR technology for wind energy. Develop and implement a LiDAR model together with a wind flow evolution model. Use the models developed to propose and study control architectures using LiDAR measurements to increase energy production and at same time minimize structural loads. One possible architecture could be a combination of feedback and feedforward control or model predictive control. The proposed solution should be tested in an appropriate simulator and compared against traditional control algorithms. Focus of the project could either be on the wind evolution model for prediction of rotor effective wind speed or on optimization of the control strategy.



The project could contain :

- Setup simulation environment
- Signal processing of LiDAR data
- Development of a wind evolution model
- Development of different control strategies
- Simulate and compare different control methods

Keywords: LiDAR; Control; Signal Processing; Wind Modelling;

Impact of heterogeneous wind conditions on wind farm control strateg

Apply!
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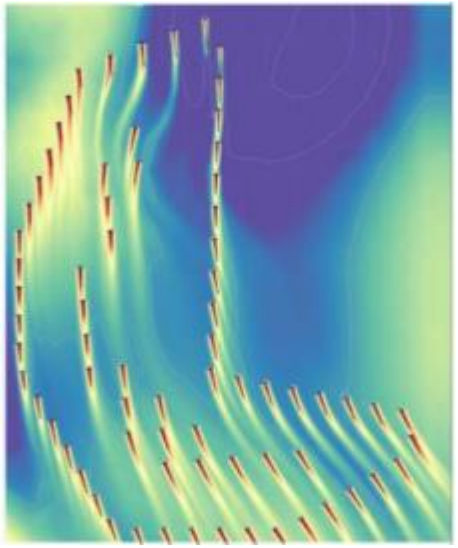
Background

Most wind turbines are clustered into large wind farms to leverage economic benefits. However, the proximity of these turbines causes them to interact through their wakes. Turbines operating under waked conditions experience lower wind speeds, reducing their power capture, and higher turbulence levels, which lead to dynamic loads on turbine components. Wind farm flow control (WFFC) is an area of research that intends to maximize wind farm efficiency by adjusting the control settings of individual turbines to intentionally manipulate the wind field throughout the wind farm. In particular, yaw-based plant level control involves adjusting the yaw angle of upstream turbines to redirect the wakes away from downstream ones, thereby achieving net power gains. This WFFC strategy has demonstrated great potential under stable atmospheric conditions and low turbulence levels, which are commonly found in offshore sites.

Scope

Current methods to define wind farm control policies and estimate respective power gains for offshore locations assume homogeneous inflow conditions. However, given the size of the wind farms, inflow conditions may vary considerably both in time and space due to meso-scale effects. The purpose of this study is to explore methods to quantify flow heterogeneity in offshore locations using data from weather models and assess its impact on the wind farm control strategy.



Keywords: Wind farm control, Flow heterogeneity, Meso-scale, Offshore

Investigation of Phase-Locked Loop (PLL) Methods for 3-Phase Power Converters under Unbalanced Grid Voltage Conditions

Apply!
Contact person: Nuno Alves
Email: nmral@vestas.com

Background

In modern power systems, phase-locked loops (PLLs) are essential for synchronizing power converters with the grid. These converters are crucial for integrating renewable energy sources, such as wind and solar, into the power grid. However, grid voltage unbalances, which can arise due to asymmetrical loads, faults, or other disturbances, pose significant challenges for PLLs. Unbalanced conditions can lead to poor performance of PLLs, causing issues such as synchronization errors, increased harmonic distortion, and reduced system stability. Consequently, developing robust PLL methods that can handle such unbalances is critical for enhancing the reliability and efficiency of power converters in distributed generation systems.

Scope

The primary objectives of this thesis are described below:

1. Literature Review: Conduct a comprehensive review of existing PLL methods used in 3-phase power converters, particularly those designed to operate under unbalanced grid conditions.
2. Method Analysis: Analyze the performance characteristics, strengths, and weaknesses of various PLL techniques, both conventional and advanced methods.
3. Simulation and Modeling: Develop simulation models for selected PLL methods using MATLAB/Simulink to assess their performance under different unbalanced voltage scenarios.
4. Performance Evaluation: Evaluate the performance of each PLL method based on criteria, but not limited to, such as response time, stability, accuracy, and robustness under varying degrees of unbalance.
5. Optimization: Propose improvements or hybrid methods that combine the advantages of multiple PLL techniques to enhance performance under unbalanced conditions.
6. Experimental Validation: If feasible, validate the simulation results through hardware-in-the-loop setup of a full-scale power converter setup.

The expected outcomes of this thesis are:

1. Comprehensive Understanding: A detailed understanding of the state-of-the-art PLL methods for 3-phase power converters and their performance under unbalanced grid conditions.
2. Performance Metrics: A set of performance metrics and benchmarks for evaluating PLL methods in unbalanced scenarios.
3. Simulation Models: Accurate and reliable simulation models that can predict the behavior of different PLL methods under varying grid conditions.
4. Optimized PLL Strategies: Recommendations for optimized PLL strategies or novel hybrid methods that offer superior performance in terms of stability, accuracy, and robustness.
5. Practical Insights: Practical insights and guidelines for implementing and tuning PLLs in real-world power converter applications exposed to unbalanced voltages.

Keywords: Power electronics, Phase locked loops (PLL), Matlab

Development of an inductive components' design tool for concept selection

Apply!
Contact person: André Mendes
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Background

Passive power filters are necessary for attenuating the switching frequency harmonics introduced by the modulation of power converters. The filters employed in a full-scale converter are of LCL-type, with usually a main inductor and main capacitor bank used. This configuration may be used on the output or input sides of the power converter, with different end purposes. Continuously increased power density needs and volume constraints present significant challenges toward inductor designs, which are usually the bulkiest components in the converter. It is, therefore, of interest to establish a tool that can generate a "optimized" design given a set of inputs (or requirements) like, volume, ambient temperature, voltage level, etc. and to generate an expected design impact for the component.

Scope

The primary objectives of this thesis are described below:

1. Literature Review: Investigate physics-based equations and mathematical formulae useful for the different design aspects of the inductor and highlight what will be necessary to derive a generic inductor design.
2. Identify inputs and outputs of the design tool: what are the necessary inputs to derive the outputs of the inductor design? E.g. I will need to know the admissible maximum magnetic flux density to define the respective magnetic core area.
3. Select tool interface for the inductor design tool and generate intuitive user interface.
4. Tool development and refinement.
5. Compare output results of design tool with real world case studies.

The expected outcomes of this thesis are:

1. Understanding the design aspects of an electromagnetic component with all its different nuances and challenges.
2. Applying the physics-based equations and translating them to a design that could be further considered for concept maturation.
3. Generating a specific tool which takes a subset of inputs and outputs a series of values that can be used for concept creation .
4. Tool can generate a design proposal. Ideally the tool can generate a design that is possible to be built and meets the criteria defined by the user (ex: Matlab Appdesigner)

Keywords: Power electronics, magnetic component design, Matlab

Design of wind turbine towers assisted by FE analysis

Apply!
Contact person: Raphael Gonçalves
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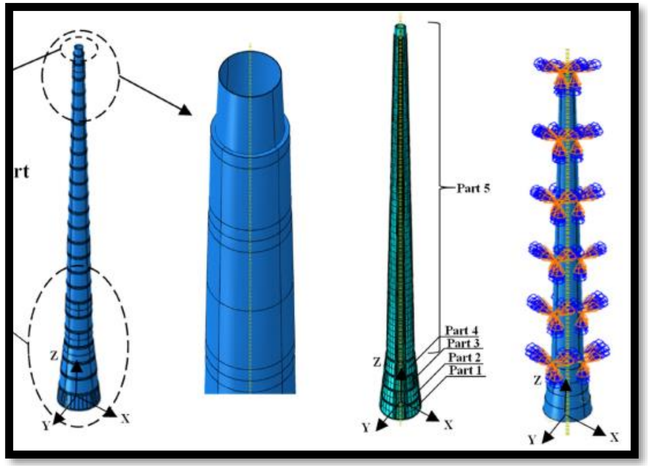
Background

Over the past decade, the exponential growth of wind energy production has led to an increase in the height of wind turbine towers. This was, in part, responding to market needs and technological advancements. The change in design has resulted in increased efficiency of energy production. The trend presents significant challenges, particularly in the structural design domain. Current design procedures rely on simplified models and analysis techniques, which may not necessarily yield optimized and efficient solutions. Moreover, new hybrid tower solutions are being developed which demand more refined analysis and design procedures.



Scope

The primary objective of this research is to assess the potential benefits of adopting advanced procedures. Specifically, those supported by detailed finite element models, for the design of a full steel tower to support the understanding of the impact on analysing concrete hybrid wind turbine towers. The study aims to contribute to the improvement of existing design methodologies, supporting optimised tower designs for the advancement of the wind energy industry. To achieve this objective, the research will focus on the application of Part 1-14 (Design assisted by finite element analysis) of the upcoming version of EN 1993 (Eurocode 3). This specific Eurocode provides a framework for incorporating finite element analysis into the design process. The methodology involves utilizing this code in the design of a selected case-study wind turbine tower.

Keywords: FE analysis; Eurocode 3; structural optimization

Design and Testing of Advanced Vortex Generators for Wind Turbines

Apply!
Contact person: Luís Oliveira
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Background

The Levelized Cost of Energy (LCoE) is the ratio between costs and AEP performance, and is commonly used to track the cost effectiveness of new solutions. Vortex generators (VG) are very often deployed on modern wind turbine blades to improve the rotor performance and their effectiveness is well proved. However, they introduce costs as well, due to their manufacturing (CAPEX) and their installation/maintenance (OPEX).

Scope

The scope of the thesis is to investigate VG improved performance by meaning of new designs which can reduce costs and part environmental foot print. CFD should be used to analyse and optimise different VG concepts. The analysis will focus on both single aerofoil analysis and rotor blade simulations. Optionally, verification by meaning of dedicated wind tunnel tests would be included in the scope.

Keywords: Wind turbine blade, vortex generator, CFD, aerodynamics, cost out, wind tunnel test

A method for the detection of oil leakages on the pitch system

Apply!
Contact person: João Lima
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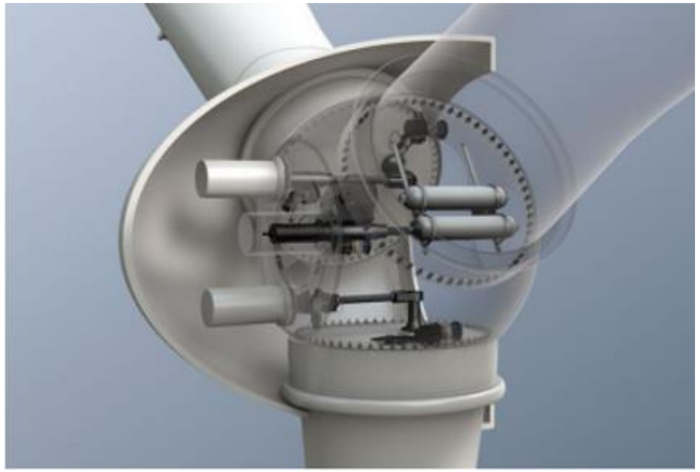
Background

The Pitch System monitors and adjusts the angle of attack of the wind turbine´s rotor blades. This system plays a vital role in a wind turbine by maintaining the optimum blade angle to achieve the ideal rotor speed or power output. A Pitch system can act either as a safety mechanism by pitching the blades to a position where they act as an aerodynamic brake, avoiding rotor overspeed, or even keeping the turbine safe in extreme weather conditions. Vestas wind turbines make use of hydraulic systems to pitch the blades since these systems are very accurate and can deliver constant force regardless of the speed. Nevertheless, hydraulic systems are very sensitive to leakages, therefore a method for the early detection of oil leakages is of high value and importance.

Scope

Propose a method for the detection of oil leakages in the pitch system.



Main goals:

- Study and understand the pitch system of a wind turbine – Identify the different components and variables of the system;
- Propose a method for detecting oil leakages on the system based on the data or sensors available at Vestas turbines;
- Create a model for the simulation of he pitch system that validates the hydraulic oil leakages detection method – Present conclusions about the research and simulation.

Keywords: Wind turbines; Pitch System; Hydraulic systems; Matlab; Simulink