Modelling and Control of Aeroelastic Tailoring Blade for Wind Turbine

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Motivation

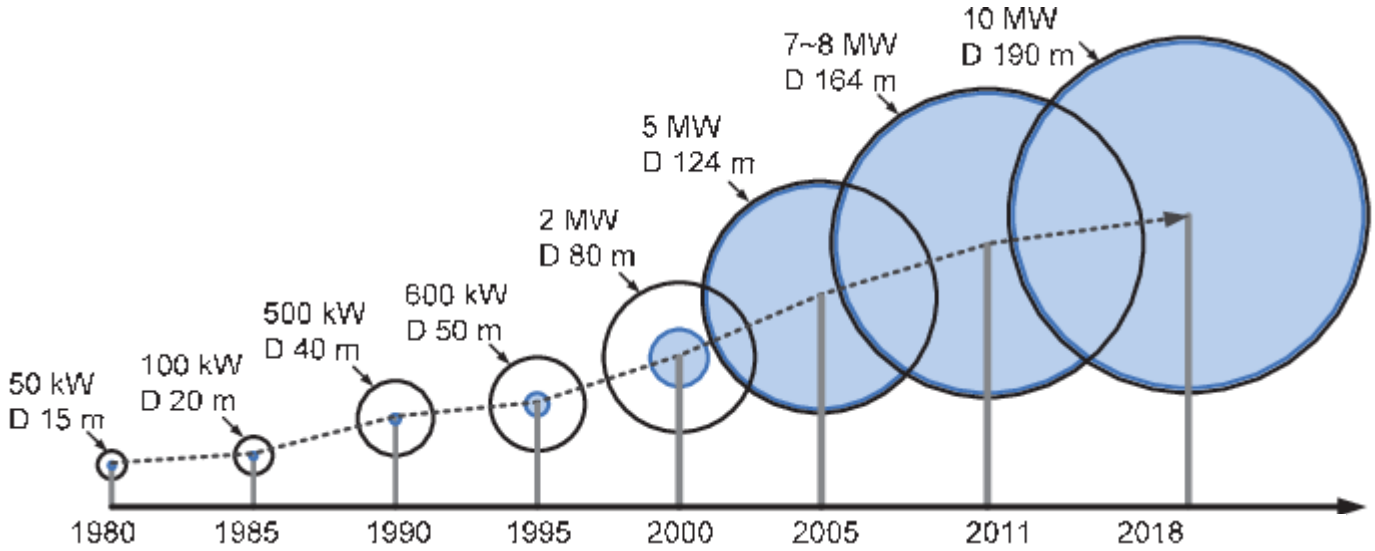

Fig 1 – Evolution of WT sizes

Source: https://www.researchgate.net/261948495_Evolution-of-wind-turbine-size-and-the-power-electronics-seen-from-1980-to-2018.

Aims

- To alleviate the loading effects in the WT system.
- To maintain the power production of the WT system.

Objectives

- To develop a reliable ATB WT model.
- To develop control strategies for both above rated and below rated wind speed.
- To investigate the performance of ATB WT model.

Aeroelastic Tailoring Blade (ATB)

- ATB WT is a WT system with a blade that has the ability to deform and reform whenever forces are applied to it.
- It is designed based on the idea of adopting the natural behaviour of plants that have bending leaves.

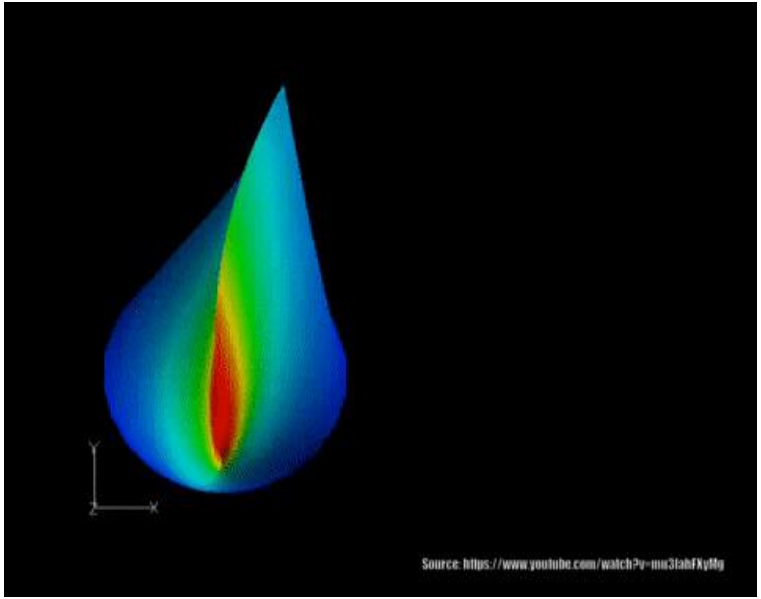

Fig 2 – ATB animation

Modelling of an ATB Wind Turbine

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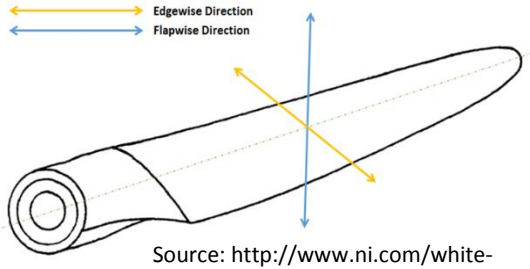
- Modelling ATB WT using Bladed flexibility modeller and including bend twist coupling (BTC) in the baseline model.
- Defining blade distribution twist angle in Bladed and analyse its dynamics behaviour.
- Modelling ATB WT in 5MW Simulink model.

Modelling in Bladed

- BTC coefficients are pre defined
- Flexibility Modeller is set to 3 modes;
- Flapwise mode
- Edgewise mode
- Torsional mode



Source: http://www.ni.com/white-paper/7676/en/

Fig 3 – Flapwise and edgewise modes

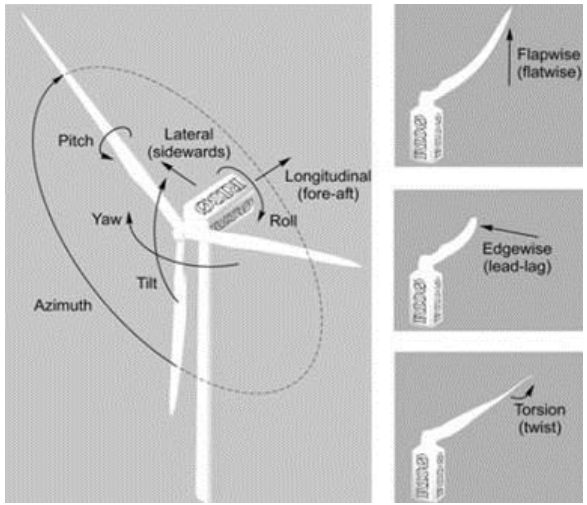


Fig 4 – Flapwise, edgewise and torsional modes

M. H. Hansen, 2007;"Aeroelastic instability problems for wind turbines"*Wiley Interscience, ISSN 1099-1824, 5 September 2007*

Control in ATB WT

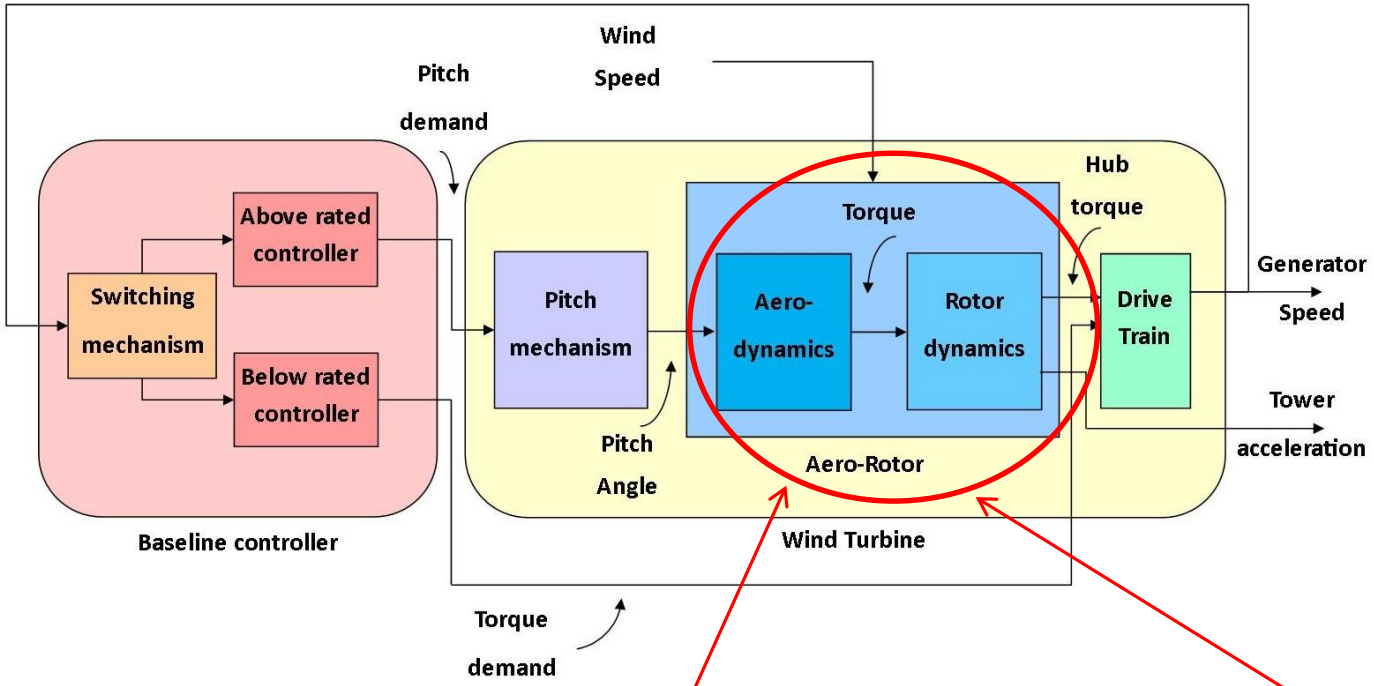


Fig 5 – Full envelope WT controller block diagram

Control in ATB WT

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- The controller is developed using the classical control theory with conventional control method and nonlinear gain scheduling techniques.
- New control parameters for ATB WT since the performance coefficient and pitch angle for ATB WT are different from the baseline.
- Bode plot of generator torque to generator speed and pitch angle to generator speed are extracted from Bladed linearisation tools.

Comparison between ATB WT and baseline WT

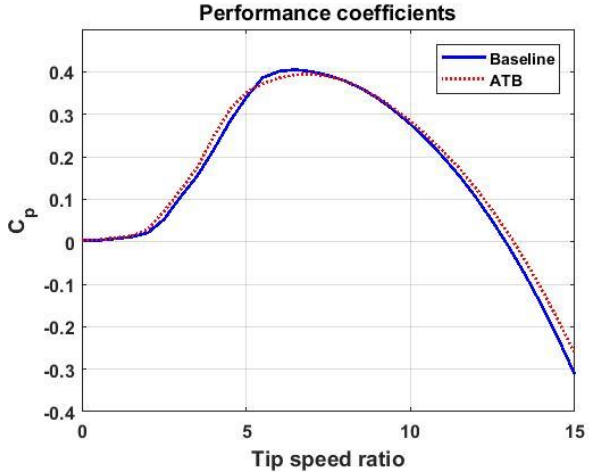

Fig 6 – Cp for ATB and baseline WT

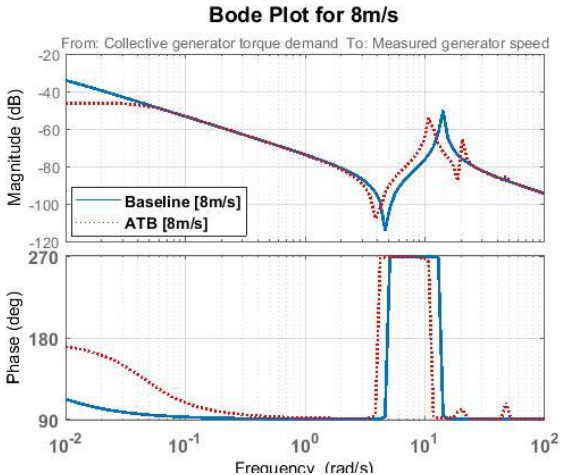

Fig 7 – Below rated bode plot for ATB and baseline WT

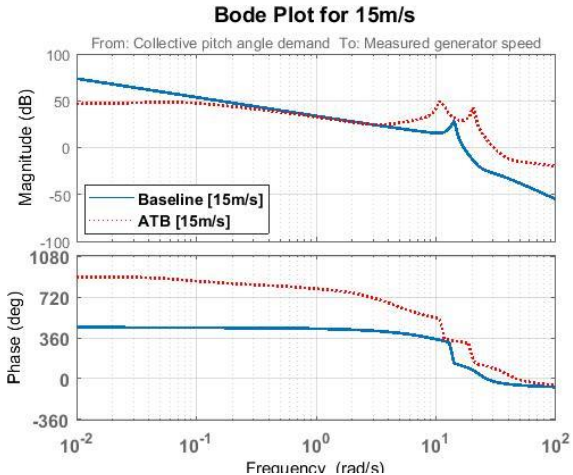

Fig 8 – Above rated bode plot for ATB and baseline WT

Conclusions

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- ATB can alleviate the loading effect in the WT system but the power production will be compromised.
- An ATB WT controller is developed to overcome the problem.
- The load alleviation in ATB WT system is a positive impact that can reduce the operation and maintenance cost for a long run.

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