Modelling and Performance Analysis of Controlled Aeroelastic Tailoring Blade Wind Turbine

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Introduction

- Aeroelastic tailoring blade (ATB) is new in wind turbine (WT) system, and the objective of ATB is to alleviate the loading effect without compromising the power production of the WT system.
- The challenge is to develop a reliable ATB model.
- The ATB model is analysed with the baseline controller.
- The ATB model is proposed by gathering and altering the available blade twist data [1], [2] in the baseline model to analyse the ATB performance with the baseline controller.

ATB twist angle distribution

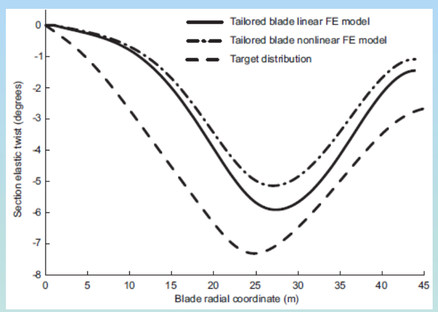

Fig 1(a) - 45m blade length [1]

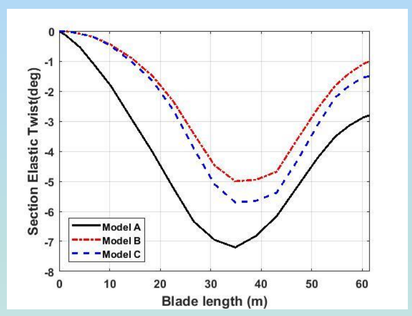

Fig 1(b) - 5MW WT, 61.6m blade length

- Model A: is developed based on standard finite element analysis (FEA).
- Model B: is develop based on linear FEA.
- Model C: is developed based on nonlinear FEA.

Block diagram

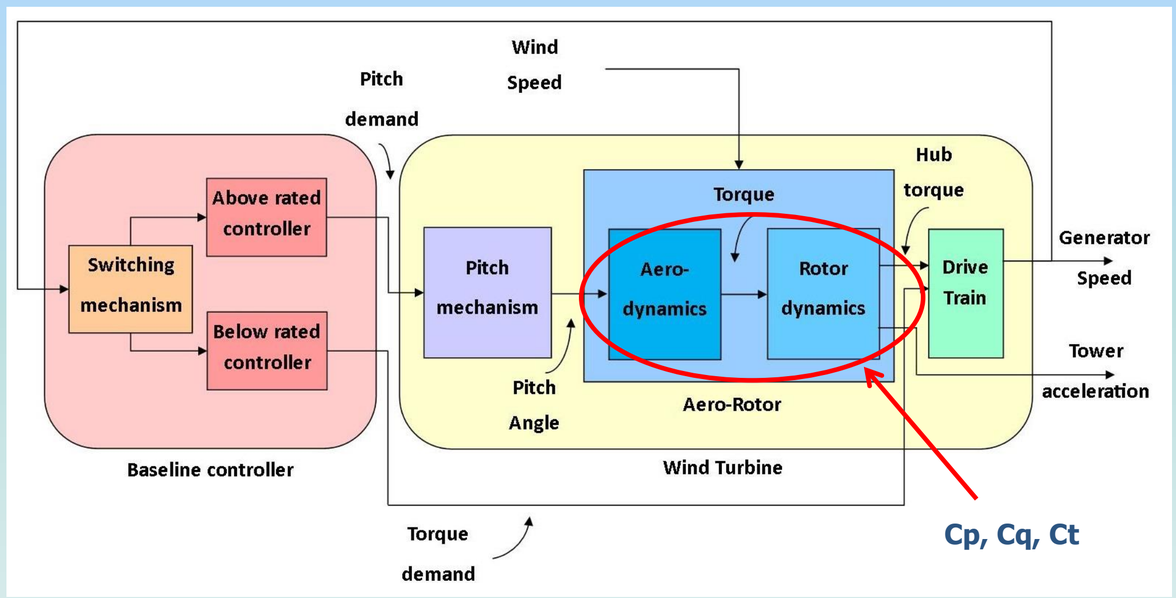

Fig 2 – General wind turbine block diagram with baseline controller

ATB dynamic model

- The wind speed changes the blade twist angles.
- And the blade twist angles vary differently along the blade section.
- New performance coefficients; power coefficient (Cp), torque coefficient (Cq) and thrust coefficient (Ct) are produced by GL Bladed simulation [3].
- For a baseline wind turbine system, wind speed is taken only as the disturbance to the system because of its stochastic behaviour.
- In ATB, wind speed is taken as the input to the look-up table to determine the ATB performance coefficients.
- The results of the performance coefficients are shown in Figures 3 – 5.
- The Cp, Cq and Ct influence the results as shown in the results in Figures 6 – 13.

ATB performance coefficients

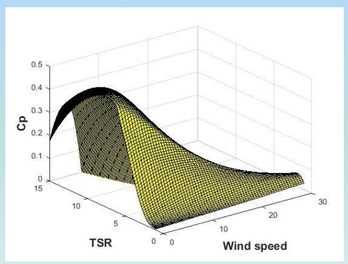

Fig 3 – Power coefficient

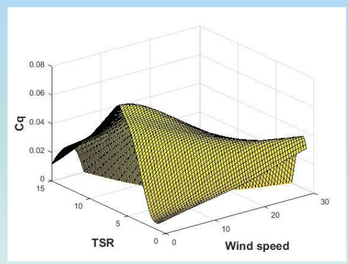

Fig 4 – Torque coefficient

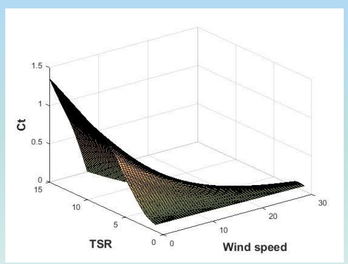

Fig 5 – Thrust coefficient

Results

Below rated 8m/s

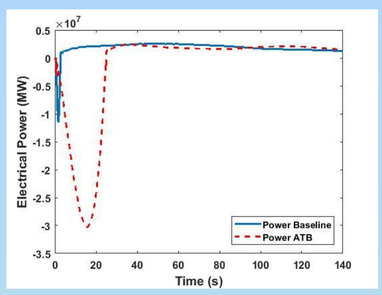

Fig 6 – Power

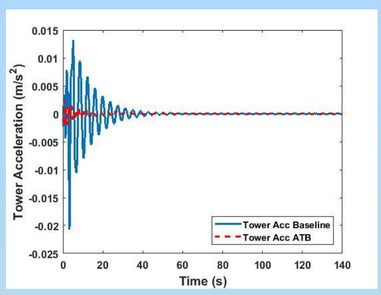

Fig 7 – Tower acceleration (TA)

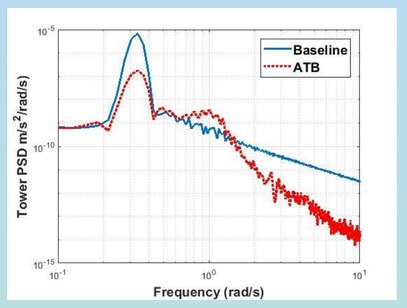

Fig 8 – Tower acceleration PSD

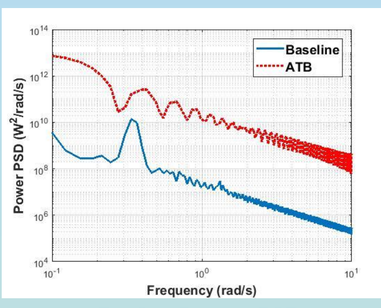

Fig 9 – Power PSD

Above rated 15m/s

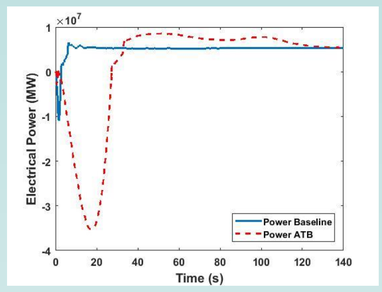

Fig 10 – Power

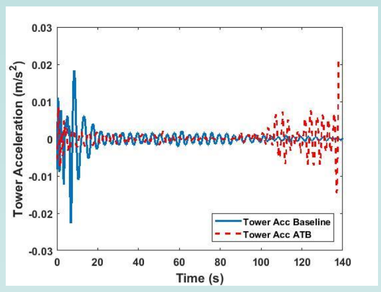

Fig 11 – Tower acceleration

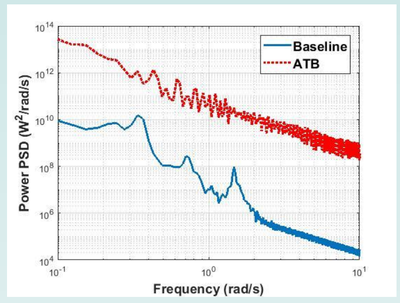

Fig 12 – Power PSD

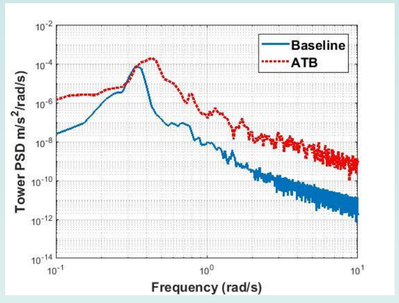

Fig 13 – Tower acceleration PSD

Conclusions

- The ATB model shows better results for below rated control.
- The power and TA for ATB model varies with small differences from the baseline model.
- However, the TA shows unstable behaviour at above rated wind speed and it strongly suggest that it is caused by the baseline pitch control mechanism.

References

[1] M. Capuzzi, A. Pirrera, and P. Weaver, Energy, vol. 73, pp. 25-32, 2014.
[2] M. Capuzzi, A. Pirrera, and P. M. Weaver, Thin-Walled Structures, vol. 95, pp. 7-15, 2015.
[3] E. Bossanyi, Gh bladed user manual, Garrad Hassan Bladed, 2009.

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