Integration and Characterisation of Piezoelectric Macro-Fibre Composite on Wind Turbine Blades for Vibration Energy Harvesting

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ABSTRACT

Vibration structural health monitoring (SHM) for wind turbine blades offers *in situ* early detection of damages within the glass fibre composite blades. This poster investigates the integration of macro-fibre composite (MFC) onto glass fibre composite in order to equip the blades with piezoelectric vibration energy harvesting (PVEH) to power the associated SHM functionalities [1].

INTRODUCTION

With the application of the wireless sensor networks (WSNs), vibration structural health monitoring for wind turbine blades offers in situ early detection of damages within the glass fibre composite blades. However, the implementation of sensor energy supply has become a challenge under this setting. Since the location of sensor placed is on the tip of the wind blade, solar and other power are impossible to be adopted due to the environmental factors. Comparatively, the energy capture of vibration itself has been considered as an effective solution during the operation of wind power generation [2].

WIND DATA PROCESSING

- The vibration data is measured at 6 m from the root of a 42 m long wind turbine blade in China through an X16-4 rechargeable data logger.
- This data logger can collect vibration data in three direction. The Z direction, as the leading factor affecting the energy harvested, is the main research direction of the experiment.

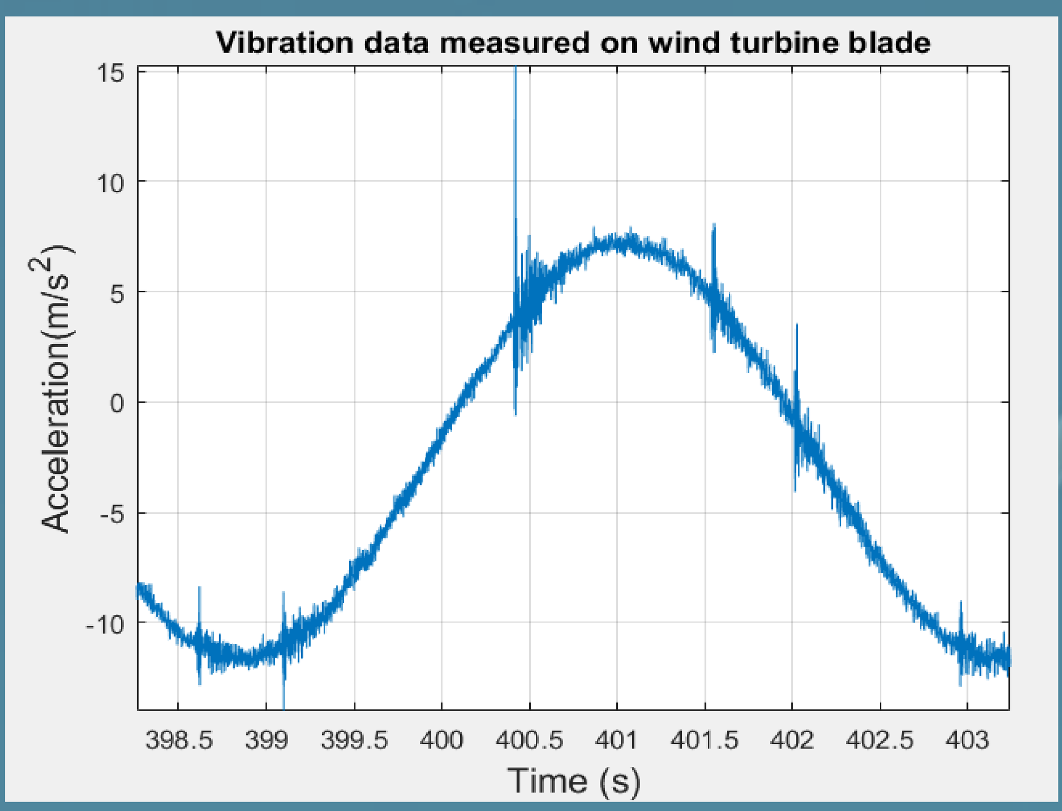

Figure 1. Practical vibration acceleration input on Z orientation.

- The vibration data collected need to filter out the effect of gravitational acceleration.

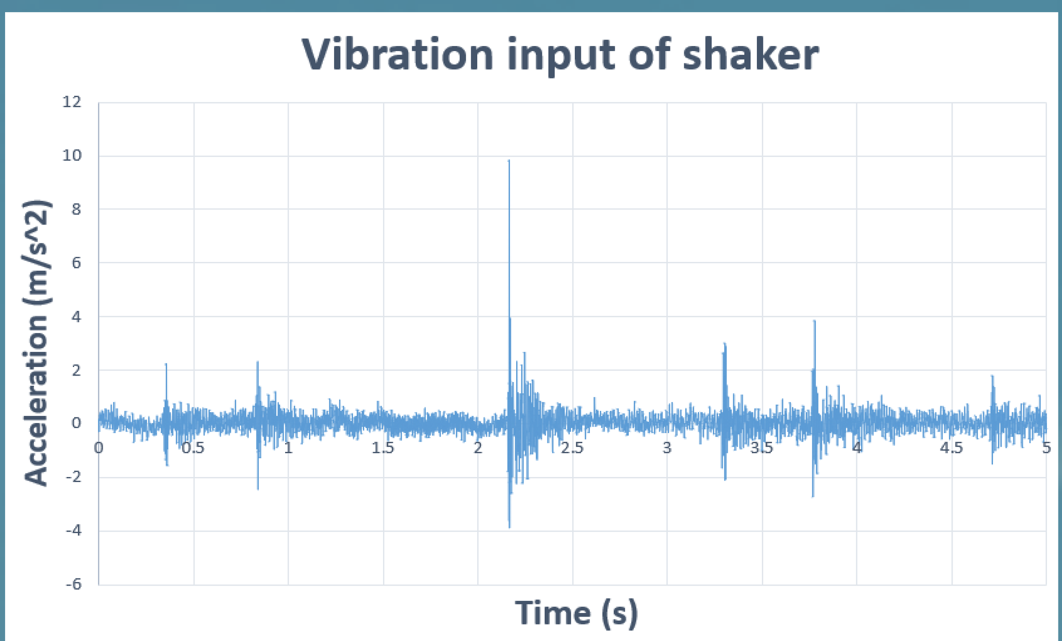

Figure 2. Vibration acceleration filtered out gravity affect.

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EXPERIMENT SETUP

- The vibration data fitted is used as input acceleration to excite the vibration shaker through the function generator and amplified by power amplifier.
- The accelerator is powered by DC power supplier.
- the MFC precured on the glass fibre cantilever transferred the mechanical energy to electrical voltage output, which is presented on oscilloscope [3].

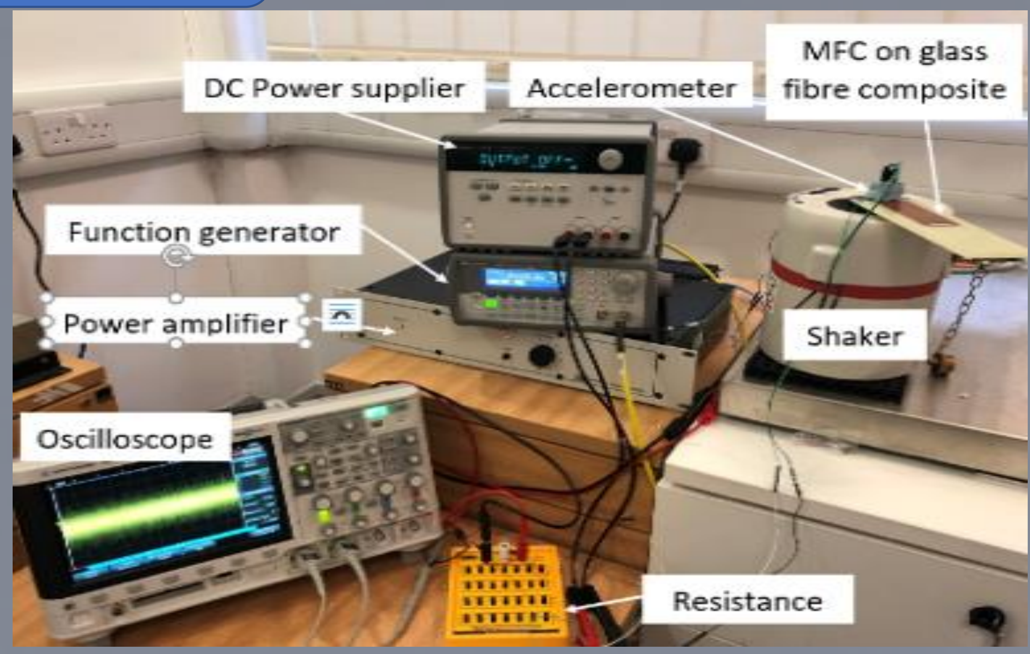


Figure 3. Experimental setup to characterise the harvester.

1. Preliminary tests and FEA simulation showed that the RMS voltage output recorded from oscilloscope is about 260 mV across a load resistance of 20 kΩ, which relates to 3.38 μW.

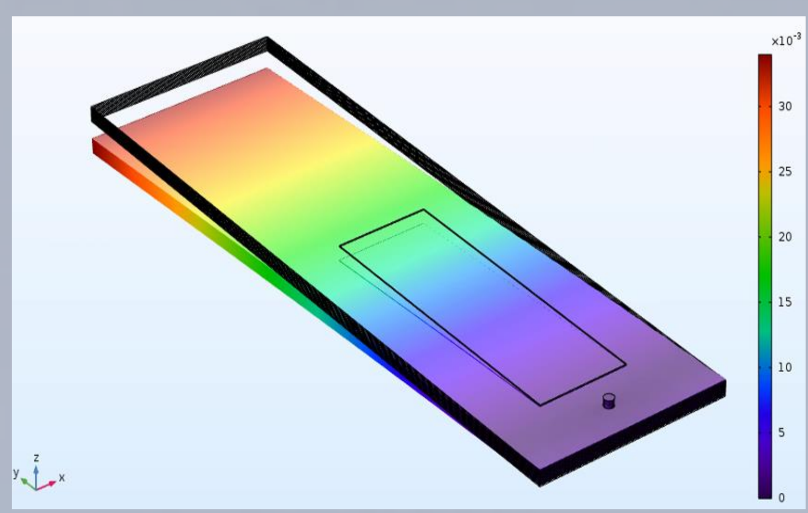
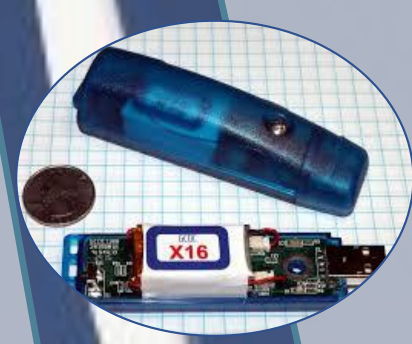


Figure 4. FEA model of glass fiber cantilever.



2. The FEA model of wind turbine is build to predict the vibration situation of blade tip.

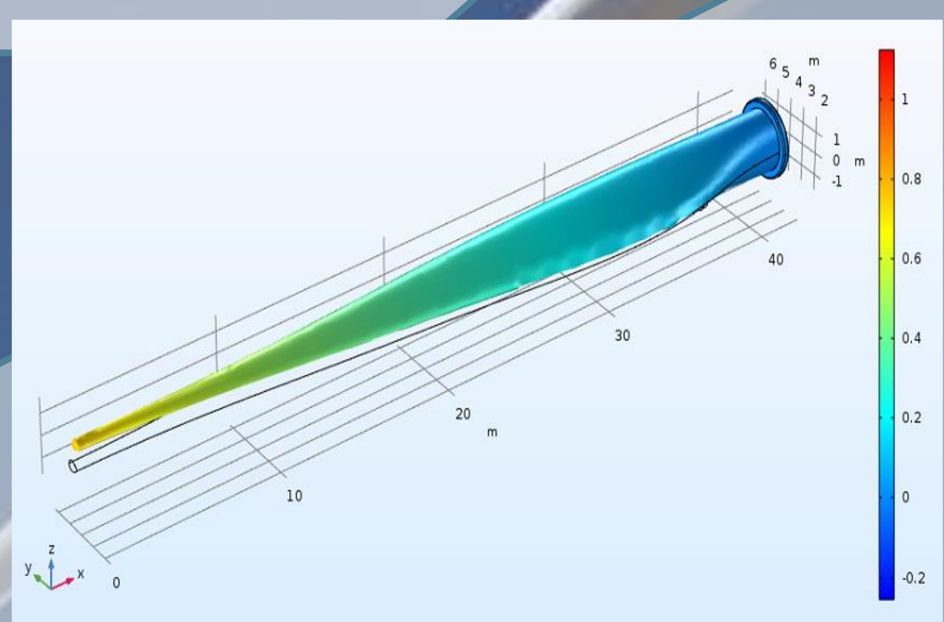


Figure 5. FEA model of turbine blades.

3. According to the FEA result, the acceleration and displacement of blade tip are shown in figure below.

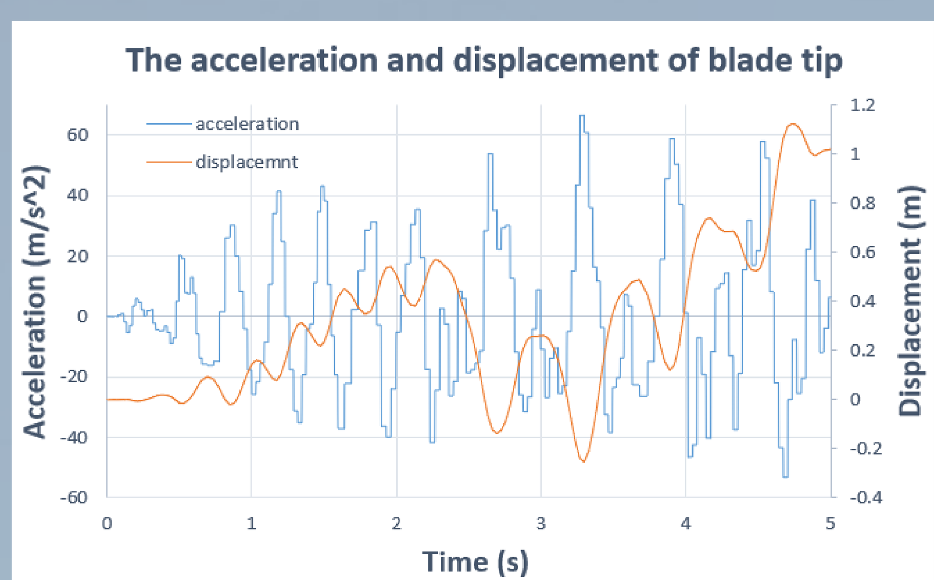


Figure 6. FEA result of wind turbine blade tip.

4. Based on the above vibration data, simulating the energy harvesting of blade tip, where thickness is 0.8 mm, and the RMS voltage is 4.46 v.

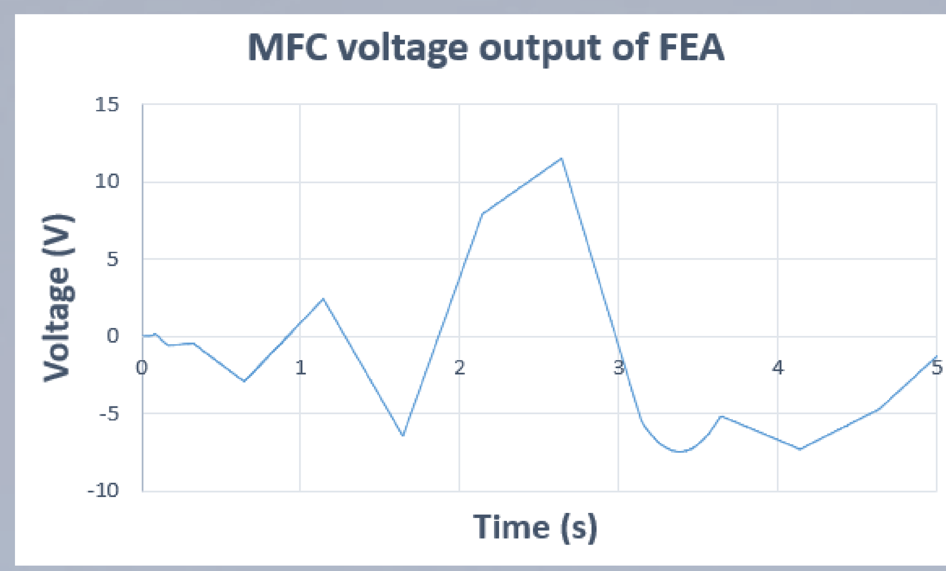


Figure 7. FEA voltage output.

5. Use spline function to smooth the FEA vibration data result.

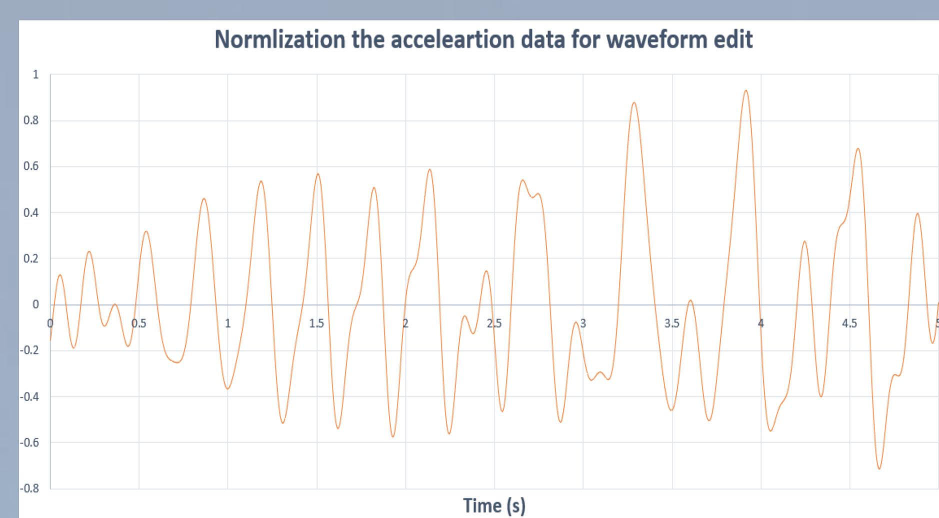


Figure 8. Acceleration data normalized for waveform edit.

6. Based on measured result, extrapolating the following voltage output, which RMS voltage is 4.10 V. Compared to the FEA simulation result, the error is less than 10%.

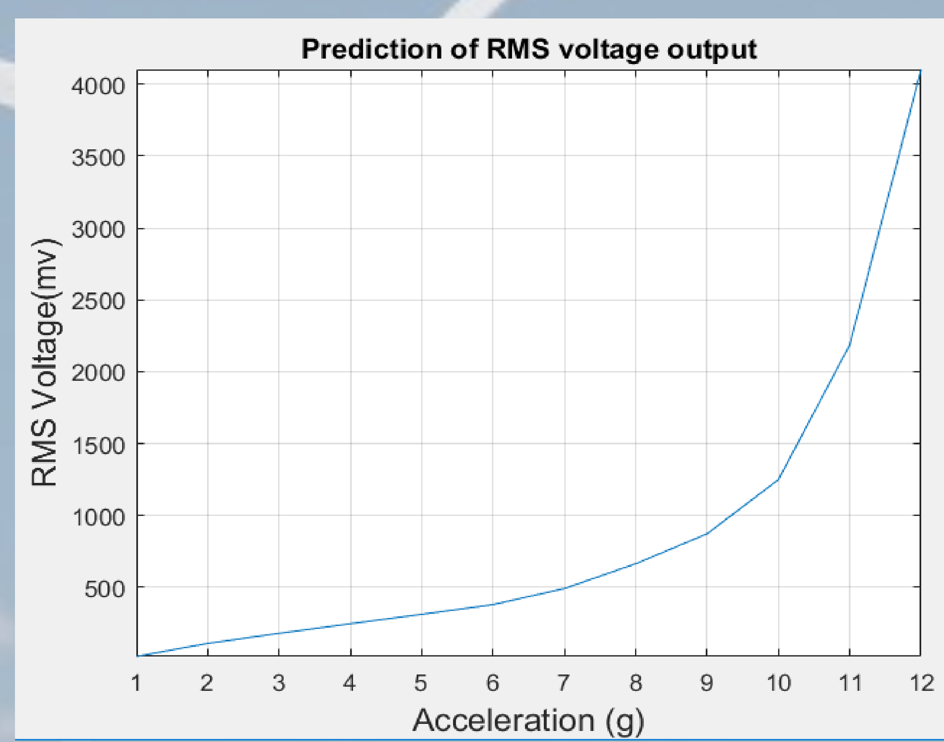


Figure 9. RMS experiment extrapolation result.

FUTURE WORK

- The 3D model of turbine blade needs to be further optimized to improve the accuracy of blade tip vibration prediction.
- A actual part of turbine blade tip will be fabricated to further verify energy harvesting result.
- Combined with the purpose of structural health monitoring, we will further verify the valuable and feasibility of its practical application.

REFERENCE

[1] Gaglione, A. *et al.* (2018), EWSN.
[2] Jia, Y. *et al.* (2019), *Composites Part B*.
[3] Shi, Y. *et al.* (2018), *PowerMEMS*.