

Life Extension of Wind Turbine Structures and Foundations

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Research Aim

Provide a technical, as well as economic analysis into fatigue damage monitoring, by application of fibre Bragg gratings embedded in wind turbine foundations.

Technical

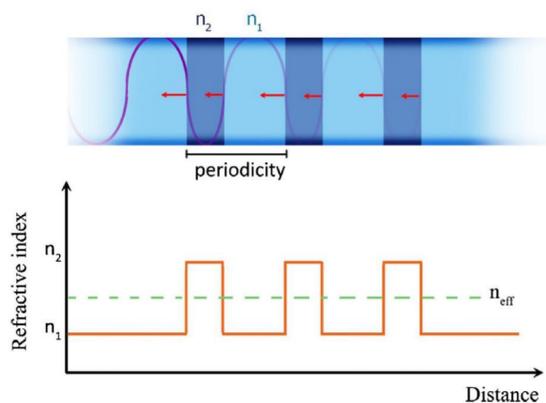
- Evaluation of sensor fatigue behaviour
- Evaluation of sensor design
- Verification of foundation FEM modelling
- Assessment of fatigue loading
- Tipping point analysis

Economic

- Model wind turbine life extension
- Evaluation of economic parameters such as: LCOE, ROI, IRR under life extension scenarios

Introduction

Bragg gratings measure strain and compression of optical fibres within the order of nano strain.



Along the fibre a periodic change in refractive index is engraved in the fibre, which reflects a specific wavelength according to the following Formula.

$$\lambda_B = 2n_{eff}\Lambda$$

This change in reflective wavelength can either be induced by strain or temperature as given by:

$$\Delta\lambda_B = C_\epsilon\Delta\epsilon + C_T\Delta T$$

[8]

Benefits in comparison to strain gauges, Fabry-Perot sensors, as well as SOFO displacement sensors:

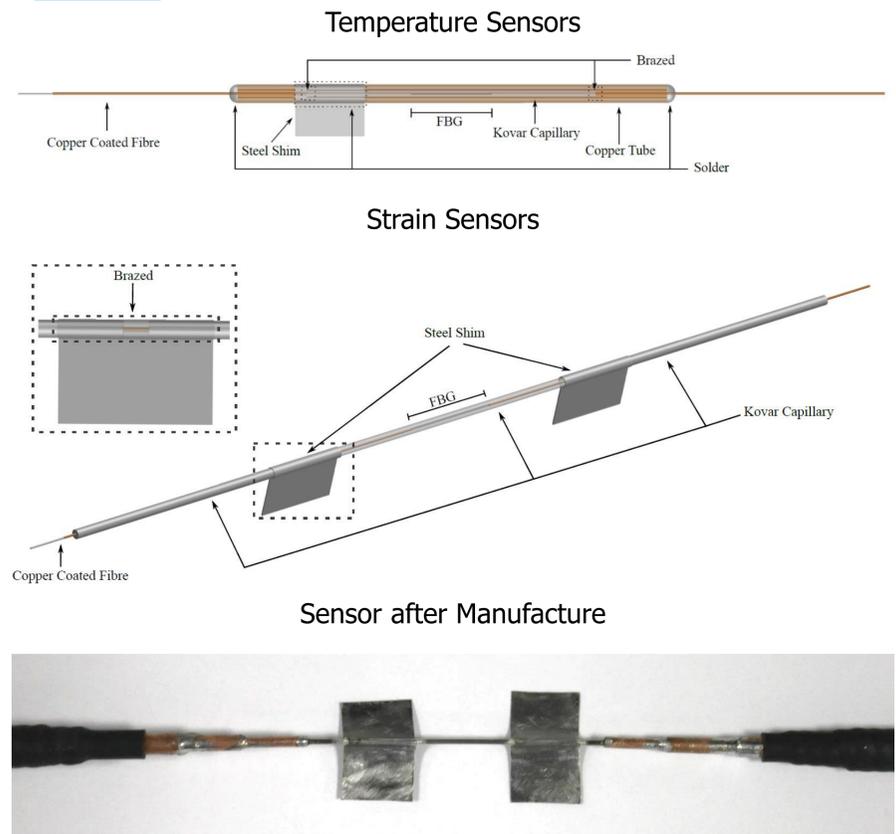
Advantages

- Multiplexing (up to 100 FBGs [36])
- Multifunctionality (temperature, strain, pressure, etc.)
- Long transmission distance - several km [27]
- Immune to electromagnetic interference (EMI)/radio frequency interference (RFI)
- Electric isolation
- Signal integrity
- Fatigue [28, 43]
- Size/weight/integration in tight areas [26]
- Linear response [59]
- Direct physical correlation between wavelength and strain [26]
- Recalibration of sensor, even after signal-processing unit has been exchanged, not necessary [26]
- Spectral shift by temperature small vs. spectral shift by strain for civil engineering application [24]

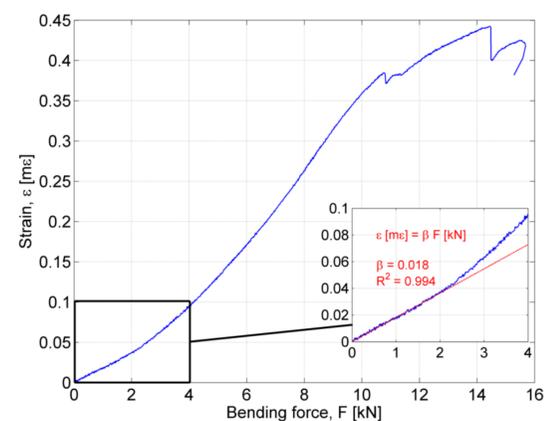
Disadvantages

- Bleaching of sensor above 500 °C
- Costs

Sensors



Static Testing



[42]

Sources

- [8] Y.-J. Rao, "In-fibre Bragg grating sensors," *Measurement Science Technology*, vol. 8, pp. 355-375, 1997.
- [41] P. Niewczas and G. Fusiek, "induction heated assisted optical fibre bonding and sealing technique," in *21st International Conference on Optical Fiber Sensors*, W. J. Bock, J. Albert, and X. Bao, Eds., vol. 7753, may 2011, pp. 77 536H-77 536H-4. [Online]. Available: <http://proceedings.spiedigitallibrary.org/proceeding.aspx?articleid=1347129>
- [42] M. Perry, G. Fusiek, I. McKeeman, P. Niewczas, and M. Saafi, "Metal-packaged fibre Bragg grating strain sensors for surface-mounting onto spalled concrete wind turbine foundations," vol. 9634, p. 963466, 2015. [Online]. Available: <http://proceedings.spiedigitallibrary.org/proceeding.aspx?doi=10.1117/12.2190188>