Development an Integrated blade condition monitoring system based on crack detection

Introduction

The Operations and maintenance (O&M) costs can contribute up to 30% of the total levelized cost of energy(LCOE) for an offshore wind turbine[1]. The contribution of blade maintenance to this cost can be significant[2]. An efficient blade condition monitoring system(BCMS) could increase the reliability and availability of an offshore wind farm and reduce O&M costs but such a system is quite complicated and challenging to produce. In a past few years, there have been efforts to develop such an effective BCMS[3] but despite this, an effective system is yet to be realized. Effective condition monitoring of a blade should comprise three elements: detection of any damage; estimation of the location and size (severity) of this damage; and prediction of the remaining life-time of the blade. A number of wind turbine blade damage detection techniques has been investigated such as vibration based techniques, acoustic techniques, thermal imaging, photogrammetry, laser imaging, etc , however the development of a reliable BCMS is still in its infancy. In this study, we try to advance this development considering the role of OMA in an integrated system.

Project description

Three methods, namely; dynamics numerical modelling of blade of Finite Element Modelling (FEM), operational modal analysis (OMA) and fracture mechanics (Smeared Crack- Fatigue Propagation Modelling), can be integrated together to construct an effective BCMS; we consider the integration of these methods in three steps:

1) Firstly, OMA is used to determine the natural characteristics such as frequency and normal mode shapes of the blade from the measured response of the blade to operational loading. These data are obtained from sensors which are installed on the turbine blade. Any deviation in the natural characteristics of the blade during operation could indicate and matching these symptoms with particular damage scenarios extracted from Combined FEM-Smeared Crack Modelling is then be used to estimate potential crack size and location.
2) Secondly, FEM-Smeared Crack modelling along with a history past failures of previous similar blade is used to build a database of different damage scenarios. Different damage scenarios can be built by using the Smeared crack modelling and by identifying the local stiffness matrix for each damage scenario.
3) Finally, fracture mechanics is used to estimate the remaining life-time of the blade from the crack size obtained from the FEM- OMA analysis.

The following flowchart shows the relationship between different parts of such an integrated BCMS

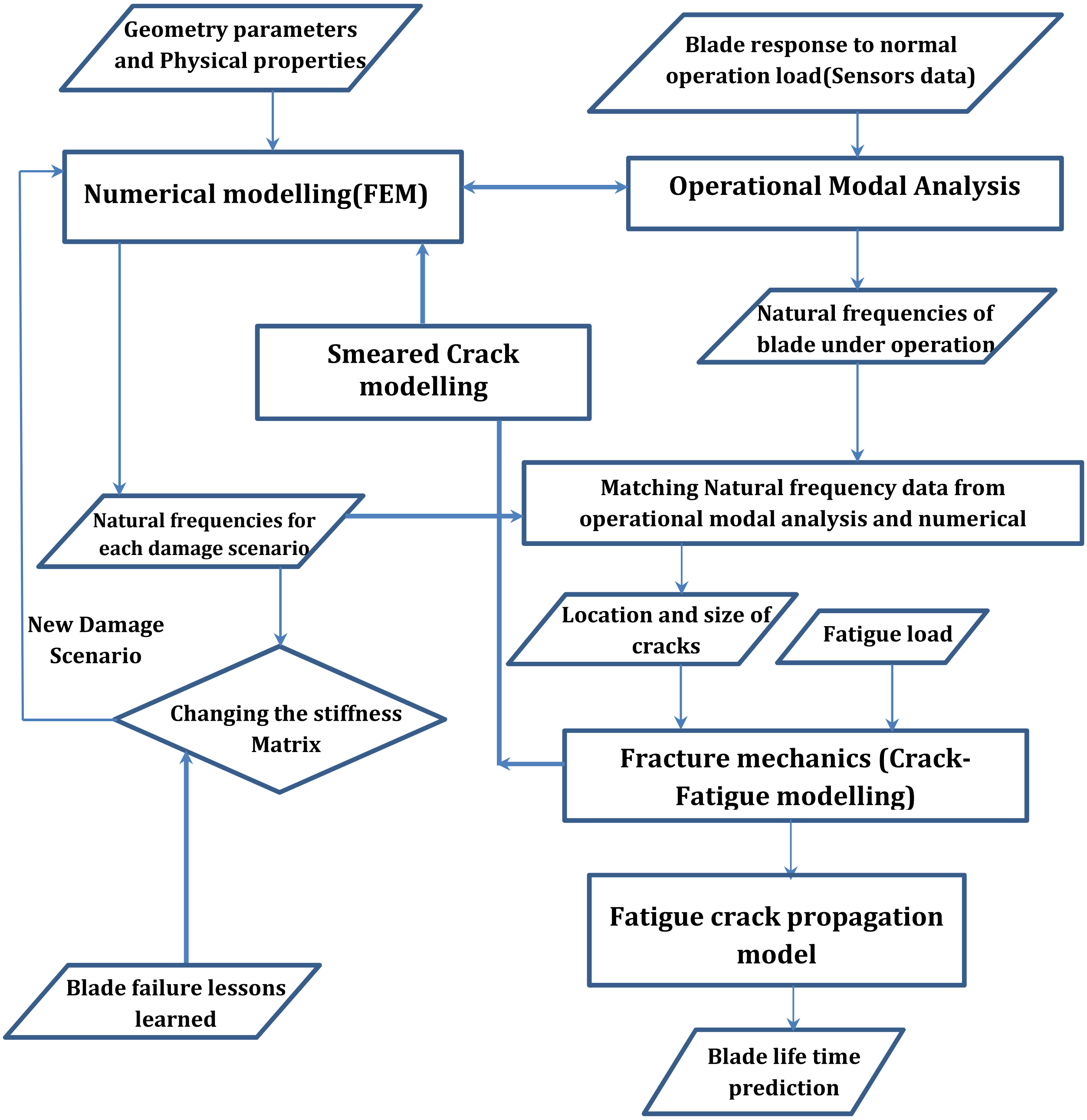

Figure 1. Different parts of proposed BCMS and their relationship.

[1] John Dalsgaard Sørensen, Jens N Sørensen. 2011 Wind Energy Systems: Optimising Design and Construction for Safe and Reliable Operation *Woodhead Publishing Series in Energy*

[2] Michael Wilkinson, Ben Hendriks , Fabio Spinato, Eugenio Gomez , Horacio Bulacio , Jordi Roca, Peter Tavner , Yanhui Feng, Hui. 2010 Long Methodology and Results of the Reliawind Reliability Field Study *European Wind Energy Conference* , Warsaw, Poland.

[3] Dongsheng Li, Siu-Chun M Ho, Gangbing Song, Liang Ren, and Hongnan Li. 2015 A review of damage detection methods for wind turbine blades *J. Smart Material . Structure*.Vol 24, 033001