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Vibration Based Structural Health Monitoring of Connections in Offshore Wind Turbines

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Abstract : The visual inspection of bolted joints in wind turbines is dangerous, expensive, and impractical due to the non-possibility to access the platform by workboat in certain sea state conditions, as well as the high costs derived from the transportation of maintenance technicians to offshore platforms located far away from the coast, especially if helicopters are involved. Consequently, the wind turbine operators have the need for simpler and less demanding techniques for the analysis of the bolts tightening. Vibration-based structural health monitoring is one of the oldest and most widely-used means for monitoring the health of onshore and offshore wind turbines. The core of this work is to find out if the modal parameters can be efficiently used as a key performance indicator (KPIs) for the assessment of joint bolts in a 1:50 scale tower of a floating offshore wind turbine (12 MW). A non-destructive vibration test is used to extract the vibration signals of the towers with different damage statuses. The procedure can be summarized in three consecutive steps. First, an artificial excitation is introduced by means of a commercial shaker mounted on the top of the tower. Second, the vibration signals of the towers are recorded for 8 s at a sampling rate of 20 kHz using an array of commercial accelerometers (Endevco, 44A16-1032). Third, the natural frequencies, damping, and overall vibration mode shapes are calculated using the software Siemens LMS 16A. Experiments show that the natural frequencies, damping, and mode shapes of the tower are directly dependent on the fixing conditions of the towers, and therefore, the variations of both parameters are a good indicator for the estimation of the static axial force acting in the bolt. Thus, this vibration-based structural method proposed can be potentially used as a diagnostic tool to evaluate the tightening torques of the bolted joints with the advantages of being an economical, straightforward, and multidisciplinary approach that can be applied for different typologies of connections by operation and maintenance technicians. In conclusion, TSI, in collaboration with the consortium of the FIBREGY project, is conducting innovative research where vibrations are utilized for the estimation of the tightening torque of a 1:50 scale steel-based tower prototype. The findings of this research carried out in the context of FIBREGY possess multiple implications for the assessment of the bolted joint integrity in multiple types of connections such as tower-to-nacelle, modular, tower-to-column, tube-to-tube, etc. This research is contextualized in the framework of the FIBREGY project. The EU-funded FIBREGY project (H2020, grant number 952966) will evaluate the feasibility of the design and construction of a new generation of marine renewable energy platforms using lightweight FRP materials in certain structural elements (e.g., tower, floating platform). The FIBREGY consortium is composed of 11 partners specialized in the offshore renewable energy sector and funded partially by the H2020 program of the European Commission with an overall budget of 8 million Euros.

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