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Offshore & Dredging Engineering

Structural health assessment through vibration monitoring on FPSO's

In the offshore oil and gas industry, production takes place at more and more remote locations, with Floating Production Storage Offloading units (FPSO's) often being selected for field development. These units may remain on station during their entire lifetime while operating under adverse weather conditions. Inspections, which have to be performed on site, are therefore becoming a challenging and risky operation. Within this context, various Structural Health Monitoring (SHM) schemes are being explored in an attempt to ensure integrity of offshore units.

The goal of this project is to study the feasibility of structural health assessment on FPSOs using vibration-based monitoring techniques, with the ultimate aim to minimize inspections of confined spaces. To this end, a typical panel structure on a FPSO hull is considered and modelled using the Finite Element (FE) method. As part of a ballast tank, the considered component is inevitably subject to structural degradation, with corrosion and fatigue cracks constituting the main degradation mechanisms. The constructed FE model is therefore appropriately parametrized in order to accommodate the simulation of the aforementioned damage conditions.

The first part of this study, referred to as the forward problem, consists of modelling the dominant degradation mechanisms experienced by hull structures of FPSO's, namely uniform corrosion, pitting corrosion and fatigue cracks. These are introduced with varying degrees of deterioration into the reference FE model of the said stiffened panel and the sensitivity of the vibrational characteristics, i.e. the natural frequencies, mode shapes and damping ratios, to these changes is investigated. The aim of this part is to extract the identifiable damage scenarios that will serve as the basis for the structural health assessment through the implementation of Operational Modal Analysis (OMA).

In the second part of the study, the so-called inverse process, the stiffened panel is assumed to be monitored during normal operation using a conventional monitoring system (i.e. accelerometers). The latter is configured in such a way that observability of all modes is accomplished and robustness of the identified properties is ensured. Excitation of the structure is assumed to be sloshing-induced impulsive loads and the measured noisy signals are processed with a set of Stochastic Subspace Identification (SSI) algorithms, upon enhancement with a cluster analysis in order to enable automatic system identification. For each one of the damage scenarios, the dynamic properties are identified and cross-compared with those of the reference model. The feasibility of damage detection through vibration monitoring, along with the existing restrictions, is finally determined and a possible extension of the proposed formulation is discussed.

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