The effect of failure criteria on risk-based inspection planning of offshore wind support structures

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ABSTRACT

Offshore Wind Turbine (OWT) support structures are subjected to harsh deterioration mechanisms due to the combined action of wind loading, sea induced load actions and corrosive environment. Fatigue failure becomes a key failure mode for offshore wind structures, as they experience considerable number of stress cycles. Fatigue failure can be assessed through fatigue assessment approaches. However, such assessments possess various uncertainties which may be quantified and updated through findings from in-service inspections. Since, offshore maintenance actions incur significant costs, an optimal maintenance strategy which balances the maintenance efforts against the risk of failure is desired to minimize the Levelized Cost of Energy (LCOE).

In risk-based inspection planning, the conventional through-thickness failure criterion is conservative for some redundant structures like jacket type OWTs. Thus, the use of Failure Assessment Diagram (FAD) as a limit state function is introduced. This paper explores the influence of fracture mechanics models and failure functions on optimal inspection planning. Two heuristic approaches, periodic interval approach and constant threshold approach are used to identify optimal interval and optimal annual failure probability threshold. Three different combinations of fracture mechanics models and limit states are analyzed for the case of a tubular joint.

Option 1: One-dimensional crack growth + Through-thickness failure criterion
Option 2: Two-dimensional crack growth + Through-thickness failure criterion
Option 3: Two-dimensional crack growth + Simplified FAD failure criterion

The following figure describes the effect of failure criteria on the updated failure probability after an inspection. Option 3 gives the smallest failure probabilities due to the assumption of capacity to hold the through-thickness cracks.

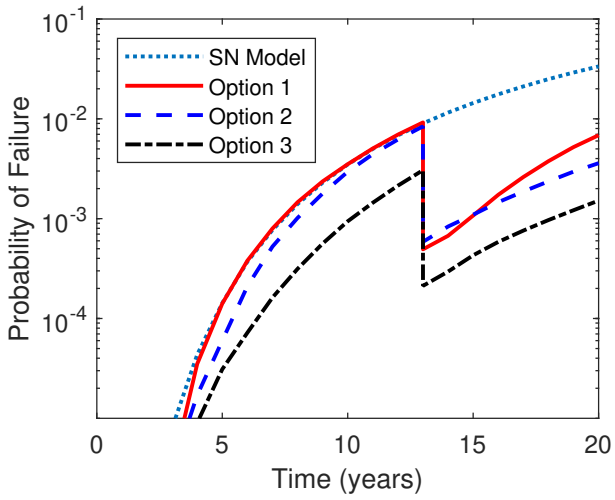

Figure 1: Updated failure probability after inspection

The analyses have proven that the choice of failure criteria can affect the optimal inspection solution. For redundant structures with high fracture toughness, using FAD failure criteria gives less total expected cost. The decision maker(s) should keep it in mind and the appropriate failure criterion should be wisely chosen depending on the properties of the material used, the nature of the structure, and the loading condition.