OUR WORK

FATIGUE ANALYSIS OF SUBSEA MINING EQUIPMENT

Head Office: PDL Solutions (Europe) Ltd

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THE PROJECT INVOLVED THE HIGH CYCLE FATIGUE ASSESSMENT OF SUBSEA MINING EQUIPMENT

PDL is a global provider of exemplary engineering design and analysis consultancy services. Our engineering capabilities mitigate risk, shorten development timescales and reduce development costs.

PDL supported a world leading manufacturer of remotely operated vehicles (ROV) used in subsea environments. The project involved the high cycle fatigue assessment of subsea mining equipment to be used in the mining of rich mineral deposits in the oceans of South East Asia. In total the chassis' of 3 different machines, each with a different function and associated set of loads were assessed. All 3 chassis' were fabricated structures weighing in excess of 40Te. The assessment was carried out in accordance with the provisions of DNV-RP-C203.

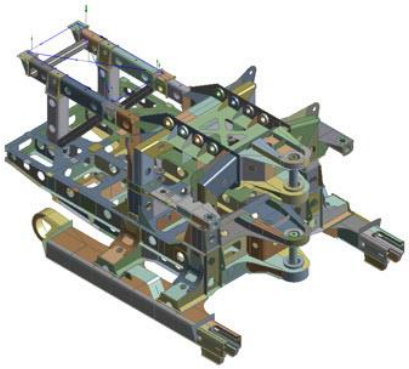

Figure 1: Shell model assembly of mining machine chassis

ACHIEVING A BALANCE IN THE LEVEL OF DETAIL WHILST MAINTAINING EFFICIENT SOLVING TIMES WAS ONE OF THE PRIMARY CHALLENGES ON THIS PROJECT

Fatigue damage calculations are highly sensitive to the stress input. As such it is imperative that local stress concentrating features such as bolt holes, fillets and chamfers are included in the model in regions of interest. Additionally, the mesh density needs to be such that the stresses extracted from the finite element model are converged and accurate. To include this level of detail on such large fabricated structures is incredibly computationally expensive and inefficient. Achieving a balance in the level of detail whilst maintaining efficient solving times was one of the primary challenges on this project.

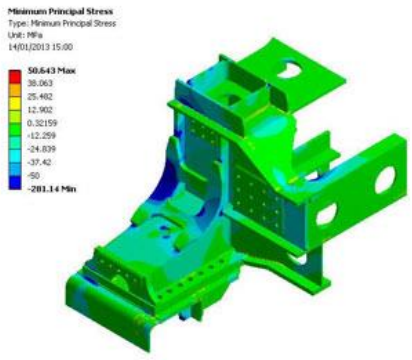

Figure 2: Cyclic stress range on solid sub-model of front track foot

THE SOLUTION TO THE PROBLEM WAS TO UTILISE SUB-MODELLING TECHNIQUES, A PRACTICE PDL HAS USED ON NUMEROUS PROJECTS IN THE PAST

Although the chassis' exhibited geometric symmetry, the loading did not. As such it was necessary to model the chassis' in full and no reduction in model size was possible. The solution to the problem was to utilise sub-modelling techniques, a practice PDL has used on numerous projects in the past. A model of each fabricated chassis was built using shell elements. The geometry was de-featured heavily by removing stress concentrating features which would not impact the stiffness of the overall structure. The shell model was then solved for the various cyclic load cases.

Interrogation of the shell model followed to identify which regions exhibited the largest cyclic stress range as these would be the critical regions in the fatigue assessment. Subsequently, smaller more detailed second order solid element sub-models were created of the critical regions. These models included all the local detail removed when creating the global shell model. The detailed solid sub-models were solved for the same cyclic load cases. At the boundaries of the detailed model, non-zero displacements extracted from the same region in the global shell model were imposed.

The cyclic stress range at each node, were input into an in-house APDL macro which calculated the damage on a nodal basis for each load case and accumulated them in accordance with the Palmgren-Miner rule. The cumulative damage at each node was subsequently plotted onto the finite element model to produce the fatigue damage contour and assess the acceptability of the fatigue strength of the structures.

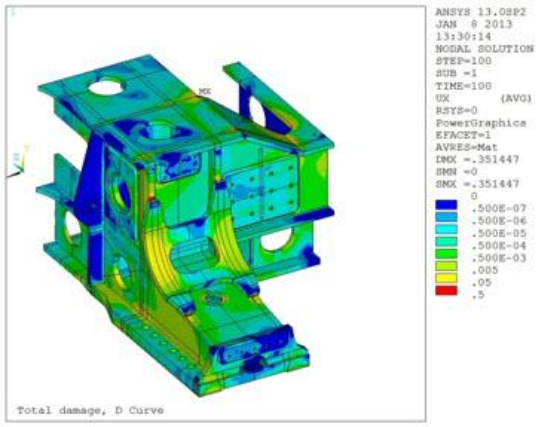

Figure 3: Cumulative damage contour of front track foot

For further information regarding PDL's engineering capabilities please email: solutions@pdl-group.com or phone our head office.