The All-Energy Exhibition and Conference 2023

Conceptual Design of Cryogenic Cooling and Cutting Method for Offshore Monopile Foundation Decommissioning

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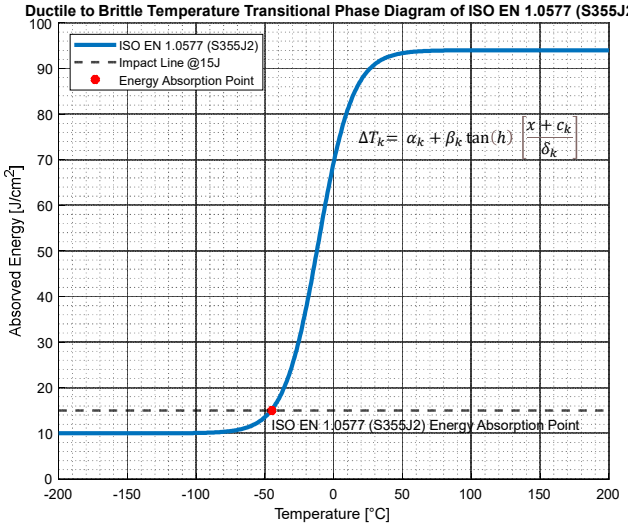

Figure 1 - DBTT Curve for the low (mild) Carbon Steel Grade of: ISO EN 1.0577 (S355J2)

The Aims and Objectives of the Conceptual Design:

1. Investigate a new cutting technique based on a low impact energy shattering method, which utilises the embrittlement concept of Ductile to Brittle Temperature Transition (DBTT) of ISO EN 1.0577 (S355J2).
2. Investigate thermal distribution and fracture propagation in Offshore Monopile Foundations (OMFs) shattering process.
3. Create a Cryogenic Cooling and Cutting Method (CCCM) Conceptual Design based on the investigations of the embrittlement cutting method
4. Evaluating the effect of the new CCCM on the overall decommissioning time and cost of OMFs.
5. Reduce the overall environmental footprint (CO_2 equivalents) by 25% and the cost of the decommissioning process by 20% for the OMFs.

Key findings from the Development of the Conceptual Design:

Define the cooling time (T_{cp}) need to reach -45 °C (228K) in the fracturing area of different wall thicknesses (W_t) of the OMFs.

By reducing the impact energy absorption from 88 J/cm² at 20 °C (293K) to 15 J/cm² within the fracture area of the ISO EN 1.0577 (S355J2) OMF wall, the impact energy absorption is reduced by roughly 83%

The new CCCM reduces the cutting time of a standard OMF with a $W_t = 100\ mm$ with roughly 23%, compared with applying the conventional Abrasive Water Jet (AWJ) cutting technique.

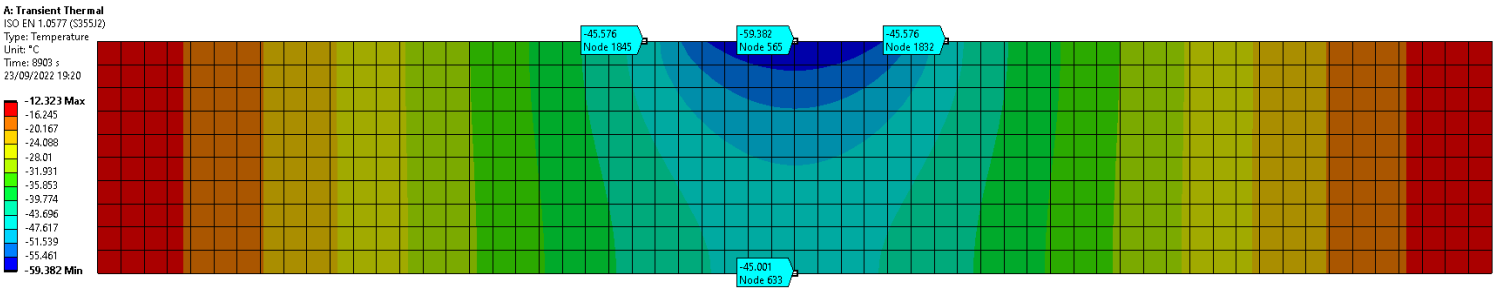

Figure 2 - Transient Heat Transfer Simulation for the OMF Wall to reach -45 °C (15 J/cm²) on the outer surface of the OMF wall

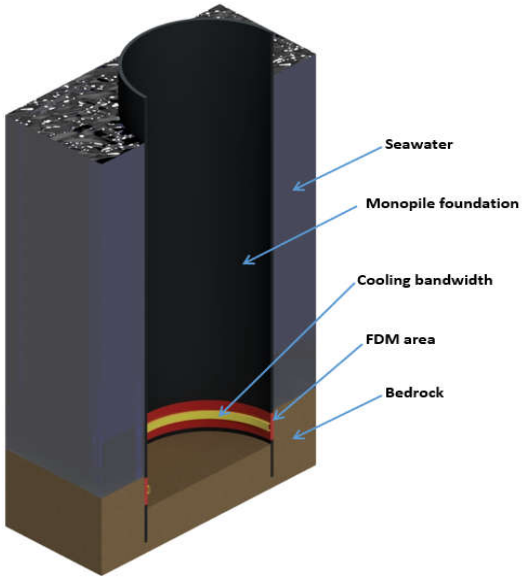

Figure 3 - 3D Model showing the OMF with the Cooling Bandwidth (in yellow) and the FDM Area (in red)

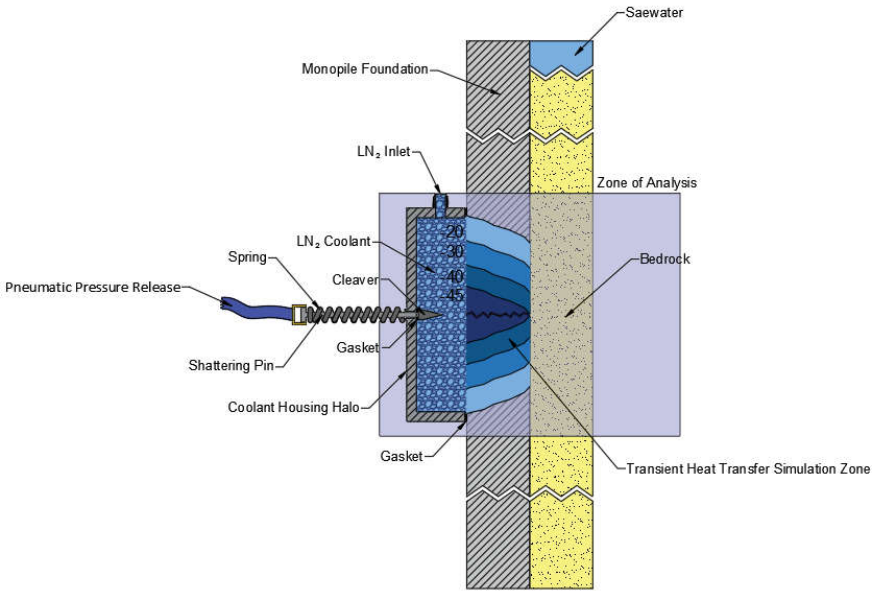

Figure 4 - Cross Section View of the Transient Heat transfer process and CCCM applied on the inside of an OMF Wall below the mudline

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