Welding Residual Stresses in Offshore Steel Structures

Background and Motivation
Supersize monopiles used for offshore wind turbine foundations are being developed and have already been installed on several offshore wind farms. The demand for fabrication of monopiles with large wall thicknesses is high. However, the implications on design and especially the welding of monopiles with these wall thicknesses are not yet fully understood. Particularly, the welding induced residual stresses needs special attention.

During welding the metal is melted by the application of extreme heat. After cooling down to room temperature, there are typically residual (internal) stresses developing in the welded joint. The stresses have a negative impact on the integrity of the welded joint, e.g. promote distortion, reduce fatigue life, and attribute to the corrosion cracking and brittle fracture in the weld components.

Research within the field of welding residual stresses is important as the size of structures and welds are rapidly increasing. The steel fabricators raise the demands, as deeper foundations are needed due to design requirements.

Purpose
This project will investigate the influence and impact of plate thickness and welding method on the welding induced residual stresses. An optimization of the fatigue design is expected, leading to a more efficient and improved design which will benefit the offshore industry. Further, it will optimize the correlation between numerical simulations and physical models.

Analysis
The investigation will be performed by means of computer simulations, experiments and in accordance with existing production procedures. The two welding methods that will be investigated are the traditional submerged arc-welding and the hybrid laser-arc welding. The thicknesses of the investigated plates are 10 mm, 20 mm, 40 mm and 60 mm. We propose to use methods such as the hole-drilling method and the neutron diffraction method to map the stress distribution. In addition, temperature measurement during welding will be performed to see the temperature development in the plates. All the measurements will be used to validate a computational weld model.

COWIfonden supports this research with the hole-drilling equipment, which will also establish the basis for further research and expertise within this topic. It will also establish the basis for more collaboration between academic partners and the industry.

International Research Consortium
This project is a collaboration between several international well-known researchers from DTU Byg, DTU MEK, Colorado School of Mines, COWI A/S, Los Alamos National Laboratory, LindøWelding Technology and Dillinger Hütte.