Qualification of Out-of-Chamber Electron Beam Welding for the Fabrication of Offshore Wind Turbine Support Structures

JOINT INDUSTRY PROJECT OUTLINE

TWI Project 35567

Date: September 2023

Project Concept

Out-of-chamber electron beam (EB) welding is a novel and high-productivity welding process developed for the welding of large tubular structures, such as monopiles.

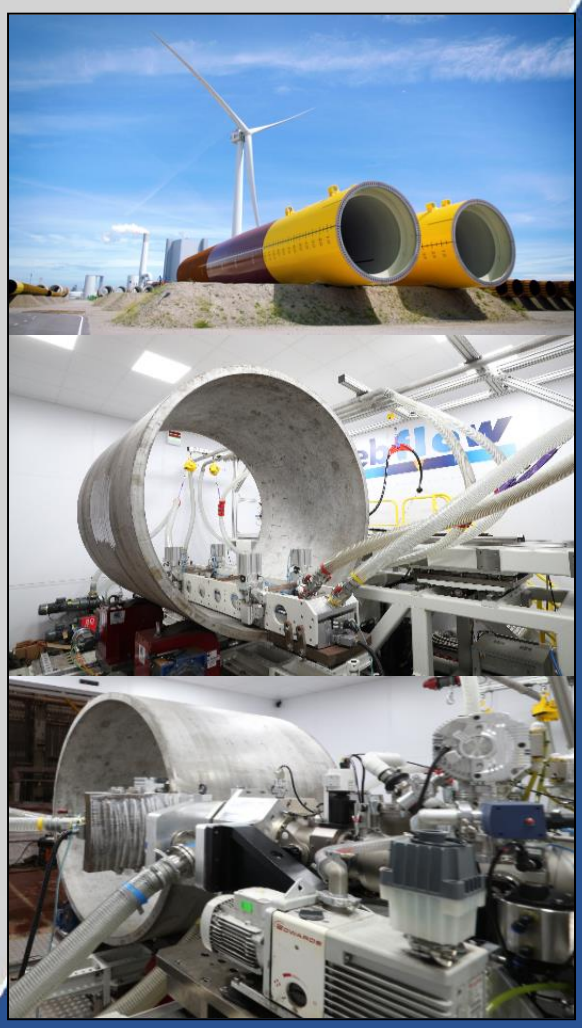
Recent advancements of out-of-chamber EB welding has shown that thick-section steels in the range of 40-160mm can be successfully welded in a single pass without defects. The RapidWeld Project (Innovate UK ref: 71824) has shown the welds have exceptional mechanical properties and fatigue strength which is at least as good as equivalent arc welds.

Significant material cost savings and a potential productivity increase of 80% can be achieved using this disruptive technology when compared to the conventional submerged arc welding (SAW) manufacturing process route.

The scope of this Joint Industry Project (JIP) is to continue the qualification of the EB welding process and generate and evaluate further fatigue data, in order to gain approval of the EB welding process for use in wind turbine support structures by the certification body DNV.

Objectives

- Further develop the EB welding process to apply to a range of thicknesses and steel grades suitable for the fabrication of offshore wind support structures.
- Generate data to further demonstrate the fatigue performance of EB welds.
- Produce a recommended practice for the use of EB welding for offshore wind support structures.



Images courtesy of Sif (top) and CVE (middle and lower)

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Benefits

This JIP will expand the range of applicability of EB welding and provide further fatigue data, forming the basis of approval of the EB process by DNV. When the use of EB welding is approved, fabricators and operators can benefit from the increased productivity that EB welding provides. If, as the initial data suggests, EB welds have a higher fatigue performance than equivalent arc welds, significant savings could be realised, through thinner wall thicknesses, or the justification of longer lifetimes.

Approach

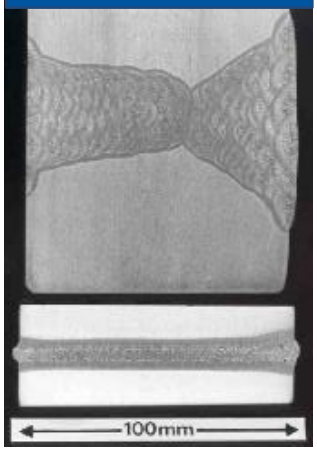
The JIP will be split into three phases of work. The choice of structural steel grades and range of thicknesses to be investigated will be steered by the sponsors to ensure that the work delivered is relevant to current and future offshore wind support structure fabrication design requirements.

Phase 1: (6m)
- Confirm 60, 80, 100mm S355ML structural steel with sponsors.
- Establish route to approval with DNV with defined welding and testing requirements.

Phase 2: (~24m)
- Weld development and testing programme taking into account the requirements identified in Phase 1.
- Mechanical testing and fatigue testing programme for 60, 80, 100mm S355ML structural steel.

Phase 3: (6m)
- Supplementary testing and data analysis from Phase 2 if necessary.
- Review the outputs with DNV. Produce recommended practice documentation from Phase 2.

Top: Conventional SAW
Bot: EB single pass weld



Deliverables

- Documented route to approval for the use of EB welding in wind turbine support structures.
- Information on key EB welding parameters for 60, 80, 100mm S355ML structural steel.
- EB weld mechanical testing and fatigue data for the 60, 80, 100mm S355ML structural steel.
- Recommended Practice for the use of EB welding for offshore wind support structures.
- Results which will be incorporated into an existing DNV Recommended Practice (i.e., DNV RP C401 or DNV RP C203, depending on the results).

Scope, Price and Duration

The current sponsors have determined the scope of work on 60, 80 and 100mm S355ML structural steel with 3.2µm Ra joint surface roughness, specific weld joint variables (i.e., mis-match and gap) to be investigated.

The price of a 3-year project which kicked off in September 2023 with DNV as a sub-contractor, is £65,000 per year, per partner.

Further Information

More information on out-of-chamber EB welding, please visit:
https://www.twi-global.com/what-we-do/research-and-technology/technologies/welding-joining-and-cutting/electron-beam-technology/out-of-chamber-electron-beam-welding

For further information on how a Joint Industry Project (JIP) runs please visit:
https://www.twi-global.com/what-we-do/research-and-technology/current-research-programmes/joint-industry-projects#/

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