LICenergy

A numerical model for TSA lab corrosion testing

In the harsh offshore environment, coating bare steel with thermally-sprayed aluminium (TSA) is now a well-tried and proven form corrosion protection. While no system is ever perfect, we are working hard to understand, model and predict the electrodynamic of the TSA around holidays, so that we can control and limit the corrosion process when damage happens.

technical feature

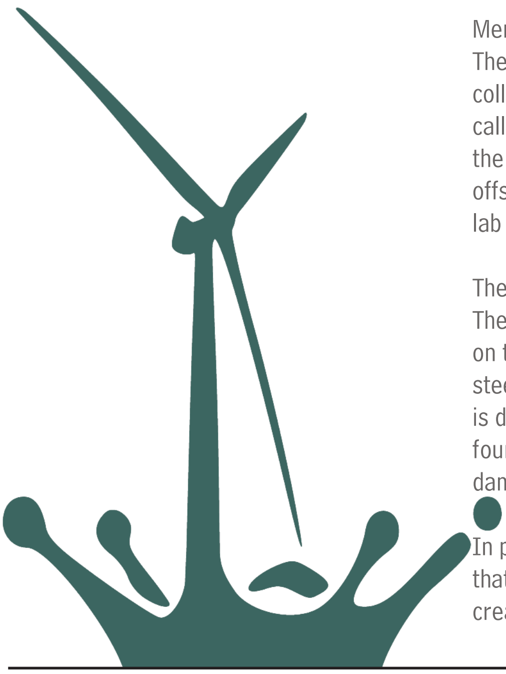
When faults do occur, their impact can be extensive and expensive. Although TSA is a highly-successful technology, the fact is that handling induced damages, simple breaks, and even hard-to-detect imperfections, can rapidly compromise the integrity of large, hard-to-reach, load-bearing steel structures in the remote deep metocean waters where the offshore wind industry now operates.

Another priority is to be able to calculate how much cathodic protection even damaged TSA coatings continue to give to primary steel exposed to salt water.

This is why at LIC Energy UK (LIC) we are working closely with The Welding Institute at TWI to develop mathematical modelling techniques that replicate laboratory testing results precisely.

Merging the theoretical and practical
The TWI-LIC project is part of a larger collaboration between 8 consortium partners called CROWN project aiming to qualify the use of the thermally sprayed aluminium compounds for offshore wind application – from manufacturing to lab and offshore testing to numerical modelling.

The TWI-LIC sub project has two parts.
The Welding Institute is running laboratory testing on the corrosion behaviour and corrosion rate of steel samples that includes a holiday. The holiday is designed to mimic a sub-sea area of monopile foundation where the TSA coating has been damaged and removed to expose bare metal.



In parallel, LIC is developing a numerical model that can be scaled-up to any size. Our aim is to create a set of calibrated parameters that can then be used to predict the life performances of TSA-the compounds, and so help maximise the corrosion protection efficiency on real in-situ structures. While many parameters are involved in actual offshore corrosion events, LIC's goal is to produce meaningful results with as few parameters as possible to avoid unnecessary complexity.

Conclusions so far

To date, the results are encouraging
Rather than overcomplicating the model with detailed descriptions of both anodic (at the TSA) and cathodic (at the steel surface) reactions, we have been able to use preliminary laboratory and field data to show that: -
The area of bare steel / damaged area is always small when compared to the TSA area implying that the TSA-to-bare steel ratio is favourable to the TSA and the steel is always polarised successfully by the TSA to the full extent of the TSA potential. The conclusion must be that a fully-coated structure is always polarised effectively. With this proved, the development focus can be switched to the current flow on the TSA coating. This is directly proportional to the corrosion rate of the TSA layer

We have also found that the current flow on the steel surface is limited by the rate of the oxygen reaction on the steel surface. As our work progresses, we will be looking for a way to link our model to the deposition of aluminium, aluminium oxide and calcareous deposits that we expect to see in laboratory testing

Our third observation is that TSA chemistry can be described and predicted by the semi-logarithmic Tafel law for electrochemical kinetics which is straightforward and used widely

As a final step at this point, we have been able to calibrate the parameters of oxygen reaction rate and Tafel coefficient until they matched exactly the total current flow from lab testing
The next stage of model development, when more laboratory data and observations are available, will be to capture the more interesting and anticipated dynamics of "species deposition", "TSA deposition" and "effect at the TSA-steel interface".

TSA as a technology

Thermal spraying is a coating process whereby molten or heated materials, including metals and alloys, are applied as micrometre-sized particles in various thicknesses over large areas at much higher deposition rates that coating processes such as electroplating or vapour deposition. As such, they are well-suited to large-scale engineering projects in aggressive environments.

TSA generally offers the toughness, low-maintenance and long component lifetimes that the offshore industry needs to measure in decades.

TWI was founded in 1946 and since 2015 has been based in Cambridge, with five other UK sites. It is one of the world's leading independent research and technology organisations specialising in materials joining and engineering processes in industry. Other TWI priorities include knowledge transfer, problem-solving, plus whole-life integrity management. The Welding Institute alone has 6,000 members.

As part of our own research mission, LIC is a member of a strategic partnership that is helping to develop and refine the TS(Z) A (Thermally Sprayed (Zinc or) Aluminium process as a robust coating system that is efficient to apply, very cost-effective and provides long-term steel protection. LIC also specialises in wind turbine monopile design and engineering.

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