OFFwind Highlights No. 5 – AUGUST 2024

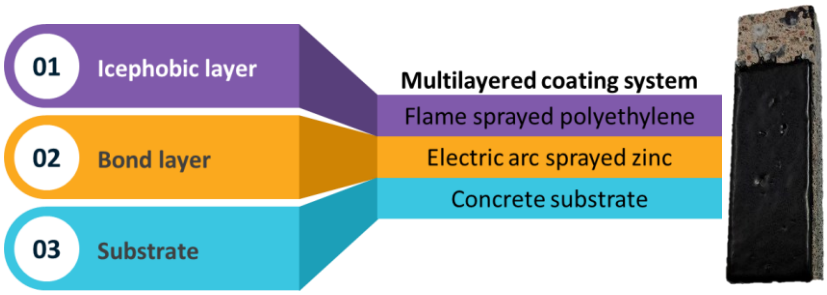
THERMAL SPRAY TECHNOLOGY

Thermal spray technology is a versatile and innovative coating process that is used to fabricate coatings on surfaces to enhance surface properties. The process is composed of melting the feedstock material and propelling molten or semi-molten materials onto a substrate to form a coating layer. Widely used across numerous industries, this technology addresses issues such as wear, corrosion, thermal degradation, and protection against other environmental stressors. It offers superior protection and performance, extending the lifespan of components, reducing maintenance costs, and improving overall efficiency.

The aim of the coating technology research in the context of OFFwind project is designing a protective coating system for concrete foundations of offshore wind turbines. Concrete protection from environmental stressors is necessary for maintaining offshore structures. Thermal spray technology offers variety of processes to fabricate protective coating system on concrete. Main environmental stressors in arctic marine conditions are corrosion, icing and wear. Therefore, the coating material should be designed to overcome these problems.

Multilayered coating design

There is not a single material that could protect the concrete from all the environmental stressors. Therefore, the idea is to employ different materials to produce a multilayered coating system. Picture 1 shows the schematic of the multilayered coating system. It is composed of substrate, bond layer and icephobic layer. The function of the bond layer is to promote the adhesion between concrete surface and the icephobic layer as well as providing protection against corrosion. Bond layer was produced by electric arc spraying of zinc (Zn). Icephobic layer then produced on the bond layer by flame spraying of polyethylene (PE). FS-PE has showed low ice adhesion strength in previous studies with pure water icing [1]. Therefore, it was selected as the icephobic layer.



Picture 1 Schematic of multilayered coating system design and a concrete sample with the multilayered coating.

Electric arc spraying of zinc (Zn)

Electric arc spraying involves feeding of two consumable metal wires into a gun, where they are electrically charged to create an arc that melts the wire tips. The molten metal is then propelled onto the substrate, forming a coating. In this work, Zn wires were used to form the bond layer on concrete. Surfaces were fully covered after the spraying process.

Picture 2 Electric arc spraying of Zn at Tampere University's Thermal Spray Laboratory.

Flame spraying of polyethylene (PE)

Flame spraying is a thermal spraying process that the feedstock material is melted by gas combustion and accelerated towards a substrate to form coating. Various materials and forms can be used, that is the main advantage of flame spraying. In this work, PE powder feedstock was used in flame spraying process to obtain icephobic coating. Smooth surfaces were aimed to ensure icephobicity.

Picture 3 Flame spraying of PE at Tampere University's Thermal Spray Laboratory.

Saline water ice adhesion

Pure water, 1 wt % NaCl and 0.1 wt % NaCl solutions were poured into molds on the sample surface to obtain molded ice at -25 ˚C. Then, the surfaces were tested with pushing test to calculate ice adhesion strength. Flame sprayed PE surfaces showed low ice adhesion strength. Detailed results can be found in the recently published IWAIS 2024 conference proceeding.

Future work

Future work will focus on extensive testing of these coatings in corrosive environment. Salt spray and electrochemical corrosion tests are planned to be conducted. Moreover, ice friction is an important factor for offshore wind turbine foundations, therefore, a new testing set-up is under development for such investigation. In order to explore possible solutions, different feedstock materials will be employed in thermal spraying process.

References

[1] V. Donadei, H. Koivuluoto, E. Sarlin, and P. Vuoristo, "Icephobic Behaviour and Thermal Stability of Flame-Sprayed Polyethylene Coating: The Effect of Process Parameters," *Journal of Thermal Spray Technology*, vol. 29, no. 1–2, pp. 241–254, Jan. 2020, doi: 10.1007/s11666-019-00947-0.

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