Université Gustave Eiffel

PhD Thesis offer

Subject : Towards a method for increasing the service life of welded assemblies in metallic structures through finishing treatment

Context & Objectives :

The thesis topic focuses on the durability of welded metallic structures, whether they have undergone finishing operations or not, at different stages of their service life. These structures can be onshore (metal bridges, wind turbines, etc.) or offshore (platforms, wind turbines, ships, etc.).

Previous research on the fatigue study of high-strength steel (HSS) welded assemblies, particularly in the case of offshore structures, has led to the development of experimental methods to investigate the influence of certain finishing processes on the fatigue performance of welded joints [1]. The results show that the crack growth kinetics are strongly influenced by the stress state (residual stress field and stress concentration) present at the weld toe [2]. Finishing operations on welded assemblies lead to an improvement in this stress state (introduction of compressive residual stresses and/or attenuation of geometric stress concentrations), resulting in a significant improvement in the fatigue performance of welded joints, especially in the long-term fatigue life domain. However, existing literature often focuses on experimental results for a single load ratio and for initial finishing (i.e., before any service and aging) of HSS. Furthermore, most studies primarily involve shot peening as a finishing method, while other equally interesting finishing methods that can increase the service life of welded joints and have fewer on-site implementation constraints (no need for a confinement area, less bulky and costly equipment) are less explored [3-5]. This thesis aims to complement existing research by extending it to conventional steels, used in the majority of existing structures, and considering all types of loading conditions, using numerical tools, capable of simulating and predicting the thermomechanical behavior from the welding phase to cooling (generation of residual stresses), and the effect of the studied finishing processes, namely ultrasonic impact treatment (UIT) and tungsten inert gas (TIG) re-melting.

From an experimental perspective, fatigue tests will be conducted on aged specimens (mechanically and/or through corrosion) that are both unfinished and finished at different stages of their service life. These tests will quantify the beneficial effects of the two identified finishing methods (UIT and TIG re-melting) and build a database of results applicable to fatigue design, calculation, and verification of welded structures. This thesis work addresses both new structures (i.e., before service), welded and finished, as well as structures already in service that have undergone fatigue or corrosion aging before finishing. In the context of renewable marine energy, the challenges related to the maintenance of existing on-site structures also justify the interest in these methods for extending the service life of structures.

The welding and finishing procedure will be defined based on the recommendations of the International Institute of Welding, the expertise developed at the SMC Laboratory, and the industrial partner SONATS Europe Technologies' feedback (for the case of UIT).

References :

[1] I. Sas, J. Lukács, Post-treatment of welding joints of high strength steels I.: improving weld geometry - overview, Multidiszciplináris tudományok, 12. kötet, 1. sz. (2022), pp. 13–27.
[2] N. T. Ninh, M. A. Wahab, The effect of residual stresses and weld geometry on the improvement of

fatigue life, Journal of Materials Processing Technology, 48(1–4), (1995), pp. 581–588.
[3] L. Dieng, D. amine, Y. Falaise, S. Chataigner, Parametric study of Finite Element modelling of shot peening on welded joints, Journal of constructional steel research, 130, (2017), pp. 234-247.
[4] A. V. Hansen, H. Agerskov, J. Bjørnbak-Hansen, Improvement of fatigue life of welded structural components by grinding, Welding in the World, 51, (2007), pp. 61–67.
[5] H. A. Al-Kharani, Fatigue life estimation of welded structures enhanced by combined thermo-mechanical treatment methods, Journal of constructional steel research, 187, (2021).

Supervision :

This work will be carried in the SMC (metallic structures and cables) laboratory at the Nantes campus of Gustave Eiffel University.
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