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Development and analysis of AI tools for welding success rate prediction and the posterior output processing of PAUT applied to welding defects detection in the ITER VV manufacturing

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The aim of this work is the development and analysis of Al tools for welding success rate prediction and the posterior output processing of PAUT applied to welding defects detection in the ITER Vacuum Vessel manufacturing.

Due to its complexity, the manufacturing of this large equipment - based on the French nuclear design and manufacturing code (RCC-MR) - has generated a large amount of data. Since the Vacuum Vessel is the first confinement barrier of the nuclear fusion installation, ensuring the quality of its welds is a serious challenge. Each of the five European sectors has approximately one kilometer of welding to be performed. Any defect in these welds results in a large disruption on a schedule and on a mechanical level, which has to be recovered, within feasibility limits. A first development of an AI tool to predict weld success rate resulted in a prediction accuracy of Electron beam welding –EBW - of almost 100%. This allows the manufacturer and the client to focus appropriate resources, dedicated time and mechanisms in order to improve on the predicted welding rate.

The Vacuum Vessel double-wall nature also results in un-inspectable welds during the last stages of the segment manufacturing on the full weld depth or from both sides through conventional non-destructive testing methods, such as radiographic examination as accepted by the RCC-MR; resulting in the need to qualify a more advanced NDT technique, such as Phased-Array Ultrasonic Testing - PAUT. PAUT data processing and interpretation has to be carried out by a human expert and requires one week per weld on average, due to the coarse grain material of austenic stainless steel used in the Vacuum Vessel - 316LN-IG - and the complexity of the qualified PAUT procedures.

This development shows that Al is an appropriate tool to process PAUT data, allowing prompter data availability and giving an additional information set in order for projects to take informed decisions. The subjective interpretation and human error factors are decreased through this automation, as is the large time required to process each PAUT output, which can be decreased from an average of a week to a matter of minutes. A successful Al application for UT has a potential to save millions in retraining.

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