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Grain structure modeling in fusion welding processes using a coupled CAFE approach - Application in NDT methods

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Fusion welding processes aim at joining parts of different compositions, geometries or functionalities by the development of a common melted zone. However, during the solidification stage and join formation, several defects such as hot crackings may develop, leading to a decrease of the weld quality. Non Destructive Testing (NDT) methods are used by industries to detect such defects using ultrasound (US) technics. However, the microstructure encountered during wave propagation in particular in the welded domain influences the efficiency of these methods. The morphology and size of grains lead to a scattering of US signal influencing defects detection, localization and sizing. Consequently, virtual grain microstructure would provide valuable information to enhance NDT technics and defect detection methods as a material of interest to analyze wave propagation.

Among approaches of interest, the Cellular Automaton – Finite Element (CAFE) method aims at simulating grain structure evolution during solidification processes. This method is based on the use of regular grid of cubic cell superimposed onto a finite element mesh. This latter enables to follow macroscopic field evolution at the scale of the domain of interest. Temperature are thereafter interpolated at cell scale in order to estimate the growth of solidification envelopes. In this work, a CAFE method simulates the grain structure formation during Gas Tungsten Arc Welding (GTAW) process applied in a chamfer configuration with added metal on a 316L stainless steel grade (Fig. 1 a). The simulated microstructure is compared with experiments developed in a partnership (NEMESIS project). A good coherence is found regarding the grain texture (EBSD map and pole figures) (Fig. 1 b) once valuable thermal conditions (e.g. melt pool shape) are obtained, using an original heat source model. Some early results associated to US method are presented based on the virtual microstructure to analyze and improve the performance of future software. Discussions are thereafter proposed for these activities as well as for the enhancement of hot cracking criterion.

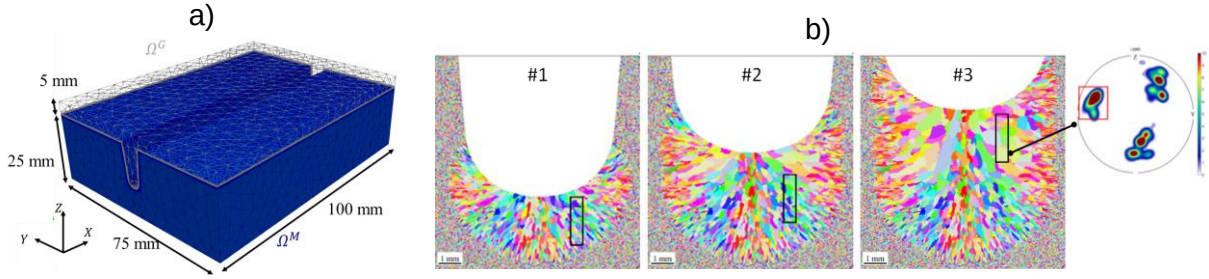

Fig. 1: a) Welding configuration, b) Simulated microstructure - three passes (CAFE) with pole figure.

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