Thermoplastic Induction Welding Simulation using a Parametric Heat Source

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The use of thermoplastic composites is growing in aeronautics because of their specific qualities with respect to damage, to their higher recyclability. In addition, innovative welding-based assembly process is bringing a key advantage to the wide deployment of thermoplastic structures, saving additional weight of mechanical connectors and paving the way for more automated production and digitally controlled assembly process.

This is a key enabler for an application to large panel and key aeronautic structure components. Among several heating process, induction welding shows the most promising efficiency. To optimize both welding quality and welding process performance of such multi-physics process, especially for laminates based on unidirectional tapes, manufacturing process simulation, based on detailed modeling of material behavior, is mandatory. Simulation unleashes the high potential of such process, speeds up its development and contributes to create a well-informed digital twin that can later be used to digitally control the process quality, once production starts. The modeling of the phenomenon of heating by electromagnetic induction involve a cumbersomeness coupling of the thermal and electromagnetic aspects.

Standard approach to model such coupling would lead to prohibitive computation times, that are simply not compatible with the process engineering timeline. To remove this bottleneck, a new approach is developed and presented in this paper. It combines an “off-line” construction of a parametric model of the heating source, taking into account all the complexity of the context of electromagnetic welding. Once constructed, the parametric heat source can be implemented in induction welding process modeling thereby providing an efficient tool to identify process parameters, securing both weld quality and optimal time and energy consumption. The method is fast in terms of computation time and can also capture nonlinear thermal behavior near edges. Validation results will be shown through comparisons between modeling results and experimental measurements obtained with a thermal camera.