Numerical Analysis of a Repair on an Impeller Using Directed Energy Deposition: Thermal and Mechanical Analysis

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Abstract

This study presents a Finite Element (FE) analysis aimed at predicting the thermal and mechanical behaviour of a repair conducted on an impeller part utilizing direct energy deposition additive manufacturing technique. The impeller, exhibiting wear on its outer edge, undergoes repair through the aforementioned technique. This repair is performed using a Beam Modulo 400 DED machine. The primary objective is to assess the deformation of the impeller post-repair, with a focus on minimizing excessive deformation. The FE model developed for this research focuses on the manufacturing process to provide insights into the thermal and mechanical responses of the repaired impeller. A key aspect of the analysis involves the calibration of the FE model, both thermally and mechanically, which was achieved through dedicated calibration prints. These calibration prints are used to collect thermal measurements and achieve predictable deformations, thus enabling the refinement of the FE model. Thermal physics plays a crucial role in the repair process, as the direct energy deposition technique involves the localized application of heat to deposit material onto the impeller surface. The FE model aims to simulate the thermal distribution throughout the repair process, enabling the prediction of temperature gradients and potential thermal stresses within the impeller structure. Furthermore, the mechanical aspects of the repair are examined to assess the resulting deformation of the impeller. Excessive deformation can compromise the functionality of the repaired part leading to rejection of the part. Through the FE analysis, parameters influencing mechanical behaviour, are investigated to predict the repair process and resulting deformation. The validation of the FE model is crucial to ensure its reliability in predicting the thermal and mechanical outcomes of the repair process. By comparing simulation results with experimental data obtained from the actual prints, the accuracy of the FE model is confirmed, enhancing confidence in its predictive capabilities. Overall, this research contributes to the advancement of additive manufacturing techniques for repair applications by providing a framework for

predicting the thermal and mechanical behaviour of repaired components. The insights gained from this study can be used for the optimization of repair processes, leading to enhanced performance and longevity of industrial components such as impellers.

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