A technical perspective on integrating artificial intelligence to solid-state welding

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Abstract The implementation of artificial intelligence (AI) techniques in industrial applications, especially solid-state welding (SSW), has transformed modeling, optimization, forecasting, and controlling sophisticated systems. SSW is a better method for joining due to the least melting of material thus maintaining Nugget region integrity. This study investigates thoroughly how AI-based predictions have impacted SSW by looking at methods like Artificial Neural Networks (ANN), Fuzzy Logic (FL), Machine

Learning (ML), Meta-Heuristic Algorithms, and Hybrid Methods (HM) as applied to Friction Stir Welding (FSW), Ultrasonic Welding (UW), and Diffusion Bonding (DB). Studies on Diffusion Bonding reveal that ANN and Generic Algorithms can predict outcomes with an accuracy range of 85 - 99%, while Response Surface Methodology such as Optimization Strategy can achieve up to 95 percent confidence levels in improving bonding strength and optimizing process parameters. Using ANNs for FSW gives an average percentage error of about 95%, but using metaheuristics refined it at an incrementally improved accuracy rate of about 2%. In UW, ANN, Hybrid ANN, and ML models predict output parameters with accuracy levels ranging from 85 to 96%. Integrating AI techniques with optimization algorithms, for instance, GA and Particle Swarm Optimization (PSO) significantly improves accuracy, enhancing parameter prediction and optimizing UW processes. ANN's high accuracy of nearly 95% compared to other techniques like FL and ML in predicting welding parameters. HM exhibits superior precision, showcasing their potential to enhance weld quality, minimize trial welds, and reduce costs and time. Various emerging hybrid methods offer better prediction accuracy.

Keywords

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