AI-Enhanced Laser Drilling of Hard-to-Machine Material

Priyanka Ghosh[1], Mohammed Begg[1], Yazan Qarout[1], Joseph Nix[1], Mostafizur Rahman[1], Sundar Marimuthu[1]

1- The Manufacturing Technology Centre, Ansty Business Park, Coventry, CV7 9JU

Corresponding author: priyanka.ghosh@the-mtc.org

Laser drilling of hard and brittle materials faces significant challenges including controlling heat-affected zones, minimising microcracking, achieving consistent hole quality, and optimising process parameters. Conventional approaches involve time consuming and often costly experimental trials to identify the suitable process parameters. Artificial Intelligence (AI) has proven successful across various domains, enhancing task performance and efficacy. However, based on a comprehensive literature review, its apparent that AI application in laser-based manufacturing remains limited compared to other areas. This paper investigates the use of AI techniques, specifically machine learning and predictive modelling, to predict optimal laser drilling parameters, including laser power, pulse frequency, and drilling speed. The study leverages secondary data such as surface characteristics and geometric outputs to facilitate AI training and validation. By analysing extensive process data, AI models can predict defect formation, such as cracks and taper, thereby improving drilling quality. Furthermore, AI-driven optimisation strategies can increase drilling speed while maintaining desired dimensional accuracy, thus reducing cycle times and operational costs. An optimal method for building a predictive model was determined by comparing and analysing different machine learning algorithms. The mean squared error of the experimental data, and the model predicted results for hole taper angle were found to be only 0.5 degrees for the RandomForest algorithm. Integrating AI into laser-based manufacturing processes presents a significant advancement by identifying optimal process parameters, predicting and quantifying defects, and addressing challenges associated with laser drilling of alumina ceramic. This integration paves the way for advancements in precision manufacturing and smart automation.