Crater identification of different pulse types in micro electrical discharge machining

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Abstract

Micro electric discharge machining (micro-EDM) technology has witnessed several research and development efforts driven mainly by the demands of watchmaking, micro-moulds and dies, cutting tools, micro-holes for aerospace and fuel injector nozzles, processing of very hard conductive materials and micromachining service to other industrial sectors. During micro-EDM, the machined surface exhibits a typical surface covered with overlapped craters which play a significant role in the precise control of component geometry, dimensional tolerances as well as surface roughness. Consequently, it is imperative to identify the material removal of each crater induced by discharge pulse. Firstly, an in-depth characterization and correlation analysis was conducted, focusing on the features of pulse waveforms and crater shapes through single pulse discharge experiment. Secondly, based on the pulse classification method, a novel continuous pulse discharge experiment was designed to successfully separate and match the pulse waveforms and craters one by one. The material removal of the workpiece under different pulse types was investigated and elucidated from the perspectives of specific energy, energy fraction entering the workpiece, and energy density. To predict crater-related parameters, machine learning and deep learning methods were employed. By comparing the regression model results with different input scenarios, it emerged that the EDM process harbors pronounced randomness and nonlinearity; underscoring the crater size is not solely determined by the processing parameters. Due to the singleness of the monitoring signal, compared with the CNN model, the ANN model exhibited the best predictive performance, with the average relative errors of crater diameter, depth, and volume standing at 8.17%, 13.22%, and 18.33%, respectively. Furthermore, the prediction error of cumulative material removal for all samples was only 1.6%, demonstrating the accuracy and effectiveness of the proposed material removal identification method based on monitored in-process signals. Different from traditional studies of material removal relying on machining parameters and statistical distributions, the approach proposed in this paper precisely achieves the characterization of the crater morphology generated by all discharge pulse types. At the same time, it has potential application in the surface finish simulation and geometric dimension control of EDM, especially for the drilling hole depth.

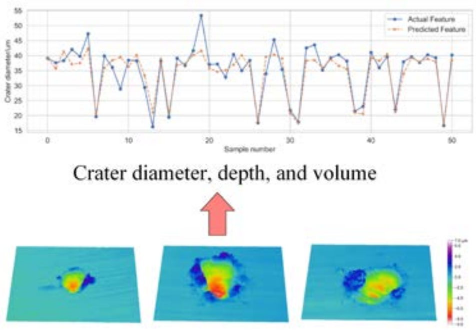

Figure: Crater-associated parameter identification of different pulse types based on machine learning method.