EXPERIMENTAL ANALYSIS INTO THE INFLUENCE OF VARIOUS VOLTAGE PULSE WAVEFORMS ON THE PERFORMANCE CHARACTERISTICS OF ELECTROCHEMICAL MICROMACHINING (EMM)

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ABSTRACT

As industrial and scientific technologies continue to advance, electrochemical micromachining (EMM) has emerged as a key technique for shaping and surface finishing metals. The aim of this research work is determined to be the invention of a simple methodology for improving the flushing efficiency and confining the current distribution within the machining gap. In order to achieve this, a novel DC step pulse waveform has been designed indigenously by a function generator and utilized as an inexpensive technique to improve the EMM performance. To get an idea about the performance of the step pulse waveform, volumetric material removal and power transmission for pulse on time have been theoretically estimated and compared with conventional rectangular pulse waveform. For better understanding, the operational mechanism of the step pulse waveform has also been investigated through simulation processes. This new step pulse waveform with various techniques, i.e., tool and workpiece insulation, microtool feed rate control, multi-step pulse, automatic pulse width modulation, automatic pulse amplitude modulation, multi-frequency modulation, has been employed innovatively in stagnant electrolyte to flush out the gas bubbles and sludge from the machining area. The most salient and unique research finding that has been observed in the present research includes the development of an electrochemical machining experimental system setup for fabricating various microfeatures on SS304 and also has tried to justify the uniqueness and originality of the present work by incorporating various novel methodologies and investigations. In the context of enhancing electrochemical micromachining performance, the machining criteria, i.e., overcut, depth, tapering effects, homogeneity, uniformity, irregularity, profile shape, and surface finish, have been investigated. The analysis of fabricated microfeatures based on a critical examination of various SEM micrographs to determine the influence of significant EMM parameters on machining accuracy and surface roughness during micromachining. One of the major contributions of the present research is that by utilizing the best parametric combination of multi-frequency modulation of the step pulse waveform, which enables the successful fabrication of precise microholes on titanium material without the need for complex electrolyte flushing and tool vibration arrangements, which are most difficult to machining by EMM. The investigation in the new field of electrochemical micromachining can be of enormous support to the present manufacturing industries because of its expected superiority of machining characteristics with respect to other machining processes. Hence, the extensive research will help to bridge the existing gap in research and knowledge by contributing to a cost-effective machining system for fabricating intricate microfeatures on challenging to machine titanium materials for advanced microengineering applications. It will also provide an appropriate platform for the commercialization of this emerging anodic dissolution process.