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Comparison of graphite, copper and tungsten-copper as materials for the precision-milling of die-sinking-electrodes

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Abstract

Die-sinking Electrical Discharge Machining (EDM) remains one of the most important manufacturing methods in the die- and mold-making sector, which is a critical part of the process chain for many vital components needed in the medical-, automobile- and aircraft-industry. State-of-the art applications for die-sinking EDM often require high-precision freeform electrode geometries, usually manufactured through milling. Furthermore, different base materials like graphite, copper and tungsten-copper are necessary to ensure an efficient EDM-process for certain applications. Companies specialized in the milling of die-sinking electrodes are therefore confronted with the challenge of achieving high surface qualities and form accuracies for very different base materials. The present study is therefore concerned with analyzing and comparing the precision-milling of freeform electrodes made from graphite, copper and copper-tungsten from a practical point of view. An exemplary freeform geometry electrode is machined from all three materials with varying milling parameters to find suitable machining conditions in all cases. The roughness of the machined surfaces is the main workpiece characteristics to be optimized. In addition, sufficient form accuracy of the electrodes is ensured by tactile contour measurements. Lastly, the milling tool wear associated with each parameter set is evaluated. It was found that the right combination of milling tool, cooling method and milling parameters like cutting velocity, feed per tooth, depth of cut as well as stepover can lead to the same high-quality process results regardless of the electrode's base material. For example, surface roughnesses Ra < 100 nm and form accuracies a_F < 10 µm were achieved. Hence this work shows, that although graphite, copper and copper-tungsten all exhibit very distinctive and different material behavior, precision-milling is a feasible manufacturing process for producing freeform die-sinking-electrodes for industrial applications from these base materials.