Manufacturing of micro bores

in high-performance materials by use of dry electrical discharge drilling

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Abstract

With the objective of an industrial application of dry electrical discharge machining (EDM), an increased understanding of this manufacturing process as well as the identification of differences to conventional EDM is required. The flushing conditions in particular differ greatly when gases are used as flushing media. Therefore, this work is focused on dry electrical discharge drilling of Si_3N_4/TiN and TiB_2 as well as Inconel 718 and PMHS 6-5-4. Carbide tubes with diameters in the range of 0.1 mm ≤ D ≤ 0.3 mm are used for drilling tests with gaseous dielectric fluids at flushing pressures of p ≤ 80 bar. Investigations of applied electrode rotation in the ranges of the spindle speed of 5 000 rpm ≤ n ≤ 300 000 rpm are enabled by two spindles for dry EDM developed at the INSTITUTE FOR MACHINE TOOLS AND FACTORY MANAGEMENT IWF of the TECHNISCHE UNIVERSITÄT BERLIN and HUGO RECKERTH GMBH, Filderstadt, Germany, respectively.

A complex numerical model is created for a detailed analysis of fluid mechanical and thermodynamic processes in the working gap between the tool and the workpiece electrode. It is found that the removal mechanisms for Si_3N_4/TiN are mainly based on the melting effect. For TiB_2, the spalling effect dominates the removal of whole ceramic grains. The experimentally validated CFD model provides insights into the fluid mechanical and thermodynamic processes in the working gap during flushing with gaseous dielectrics for the first time. In contrast with the assumptions and despite local supersonic flow, the flushing capacity is ten times lower for gases at similar flushing pressures. Moreover, the electrode rotation applied causes radial velocity components in the circumferential direction, which locally make up one third of the velocity components in the main flow direction.