EXPERIMENTAL CHARACTERIZATION OF ELECTRICAL DISCHARGE MACHINING PLASMAS

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Plasma created during electrical discharge machining (EDM) is systematically investigated with imaging and with time- and spatially-resolved optical emission spectroscopy. Analysis of the pre-breakdown duration shows that the breakdown is of stochastic nature. Due to presence of gas bubbles created by electrolysis, the breakdown mechanism in water could be different from the one in oil. After the breakdown, the plasma develops very fast (< 50 ns) and then remains stable. While the gap distance is estimated around 10-100 μm, the plasma excites a broad volume around the electrode gap, between 50 and 400 μm in diameter depending on the discharge current. Typical spectra show a strong H_α and continuum radiation, with many lines emitted by impurities coming from electrode and workpiece materials. Hydrogen atoms come from the cracking of the dielectric molecules. The plasma contamination from the electrodes, measured with spatially-resolved spectroscopy, is found to be mostly concentrated in their vicinity. Time-resolved spectroscopy shows that plasma density reaches $2 \cdot 10^{18}$ cm^{-3} at the beginning of the discharge. This extreme density causes merging of lines, strong Stark broadening and shift of the H_α line. The density decreases afterwards rapidly with time. The electron temperature remains roughly constant around 0.7 eV. The low temperature and the high density measured prove that the EDM plasma is non-ideal ($\Gamma \approx 0.45$). Absence of the H_β line, asymmetric shape of the H_α line and complex structures around H_α are other spectroscopic evidences of the plasma non-ideality. After the discharge, light is still emitted by incandescent metallic particles coming from erosion of the workpiece.