Dielectric Fluid Flow in Die-Sinking EDM Gap
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1. Introduction
Ejection of debris from the working gap in EDM is an important phenomenon for stable and precise machining. Therefore, the relationship between the flushing action of the electrode and the behavior of the debris is of technical interest [1,2]. Recently with the help of high-speed jump function of linear motor equipped EDM machines, the debris disposal has improved even for deep machining for no-flush machining [3]. This paper deals with the dielectric fluid flow in working gap during electrode jump for different jump rates and heights.

2. Experimental Analysis
A dummy electrode-workpiece is fabricated to simulate the real dielectric flow in working gap, where the dummy electrode moves with the same real machining jump parameters. The observation and flow visualization in the model gap are carried out by using PIV (Particle Image Velocimetry) technique (Fig.1). In this technique, the images of glass powder particles (ø22µm) put into the fluid are recorded with a high-speed camera (maximum speed of 10,000 fps) and then interrogated with a PIV software package to understand the flow characteristics of the dielectric fluid. The analysis showed that, a side gap vortex is generated during the descending period of the electrode jump (Fig.2(a)(b), where side gap=0.2mm, bottom gap=0.5mm, jump speed=15m/min, jump time=0.3s). In real machining, this vortex is supposed to capture some of the debris that is trying to flow out of the gap by the effect of jump flushing. The captured debris will increase the debris concentration at the side gap resulting in secondary discharges between the workpiece and electrode. These secondary discharges are considered to be the main cause to obtain concave side surfaces, especially in deep machining.

3. Computational Analysis
The electrode jump motion was modeled and the flow field in gap was simulated using CFD (Computational Fluid Dynamics) calculations. The 2-D flow in gap was modeled for electrode jump heights of 2 and 10mm and jump time of 0.16s, with bottom and side gaps of 0.1 and 0.2mm, respectively (Fig.3). The jump motion was simplified to a sine wave function since it was close to the real jump motion. The analysis was done by assuming that the kerosene fluid flow in gap is laminar and unsteady for fluid density of 760kg/m³ and dynamic viscosity of 1.881x10⁻⁶ m²/s. The CFD calculations showed that for different electrode jump speeds and heights, a side gap vortex is again generated during the descending period of the electrode jump (Fig.4(a) for jump height=2mm, (b) for jump height=10mm). Since higher electrode jump pumps more dielectric into the working gap, the debris concentration in gap is lower for high electrode jump machining compared to low jump machining [1]. This result when combined with the CFD results may show the correlation why the concavity of the EDMed holes becomes smaller with higher electrode jumps.

4. Reference