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Particle hydrodynamics of the electrical discharge machining (EDM) process – Part 1: Physical considerations and wire EDM process improvement

Haas Patrick[a*], Pontelandolfo Piero[b], Perez Roberto[c]

[a]*Professor, University of Applied Sciences Western Switzerland, HEPIA, Rue de la Praire 4, 1202 Geneva, Switzerland*
[b]*Research Assistant, University of Applied Sciences Western Switzerland, HEPIA, Rue de la Prairie 4, 1202 Geneva, Switzerland*
[c]*Head of Applied Research, Innovation, EDM Unit, AgieCharmilles SA, Rue du Pré-de-la-Fontaine 8, 1217 Meyrin, Switzerland*
* Corresponding author. *E-mail address*: patrick.haas@hesge.ch, http://www.cmefe.ch

Abstract

During these last years, the evolution of the machining speed of the EDM processes has become a key challenge for this technology. The recent progress made on the spark generators leads to a higher production speed in all processes such wire EDM, die-sinking, drilling, milling, etc. Nevertheless, if the electrical process is developing fast, many limiting factors still remain under investigations. In this context, our group started 7 years ago a research program to increase the understanding of the EDM particle hydrodynamics. We describe in this paper some results obtained and discuss the physical aspects related to the evacuation of the machining debris.

During the EDM process, if the cleaning of the dielectric is not effective and some debris remain in the gap, the electrical resistance is locally reduced and the spark occurs at the same place. The process cannot go farther. In this situation, i.e. when the spark frequency and power are high enough, the machining speed is governed mainly by hydrodynamics. In this paper we will present efficient strategies to clean the gap in the wire EDM (part 1) and die sinking processes (part 2).

For the wire EDM process (part 1), we have designed and analysed dielectric injection nozzles with the aim of improving the cleaning processes in the gap. Three main tools have been used to achieve this goal. The first is a fluid flow simulation model using CFD solvers. Then, the results have been validated using experimental techniques at full scale on EDM machines. Finally, a test rig has been developed and experimental analyses have been done.

Keywords: Wire EDM; WEDM; particles; cleaning; hydrodynamics; CFD; experiments

1. Introduction

In the EDM process (Fig. 1), the plasma generated during the heating phase leads to the presence of liquid material and gas. When the plasma disappears, a pressure wave is generated that move the melted material in the dielectric. Solid particles are formed (Fig. 2). A crater is formed; this is the machining action (Fig. 3). The particles remain in the dielectric closed to the crater (Fig. 4). These have a spherical shape and move in the liquid. The density of these is higher than the liquid, then the trajectories of the debris are not directly which of the fluid particles. They need to be observed or calculated, according to the laws of the motion of a high density solid in a fluid flow. The forces are the hydrodynamic force, the hydrostatic force (Archimedes' force) and the mass forces (gravity and acceleration).

The EDM process needs some impurities in the dielectric liquid. If these are not present sparks cannot be generated. At the other hands, if the impurities are in big quantities and located at the same place, the spark will