METALLOGRAPHICAL ASPECTS OF THE ELECTRICAL DISCHARGE MACHINING OF HARD SINTERIZED ALLOYS

Valentin Petrescu a
Toderiţa Nemeş a

a The Lucian Blaga State University of Sibiu, Emil Cioran nr. 4, 2400 - Sibiu, Romania, cstm@ulbsibiu.ro

Abstract:
The paper presents some experimental measurement of hard sintered alloys, G40 type of metal carbide material during the electric discharge machining process. Metallographic analysis was made to show the cracks from the superficial surface layer and the influence of the pulse period over the nature of the material during the EDM process.

1. THE EXPERIMENTAL MEASUREMENTS
The experiments have been realized with aluminum samples of hard sintered alloys G40 (20% Co, 50% CW).
These experiments have been realized with an EDM installation called ELER-01 and GEP-50F. It has been used electrolytic copper electrodes that are easy to be processed with a cylindrical pipe form type and the exterior diameter $d_e = 10 \pm 0.1 \text{ mm}$, as showed in figure 1.

Figure 1. The electrolytic copper electrodes with a cylindrical pipe form.

The dielectric liquid used was the winter diesel oil 15A STAS 240-88. The liquid’s pressure was 0.1 Barr, its increasing value making an easy phenomenon of cleaning the working surface of the processed particles, which influenced in a negative manner the discharge phenomena and increasing the wearing process.
The samples have been processed in a coarse regime as showed in figure 2 and have been sectioned before the preparing for the metallographic analysis.

Figure 2. Samples processed by Wire-EDM.
The machining process have been realized with the specific parameters, as showed in table 1, during the working regimes, both, coarse and finishing regimes.

**Table 1. Processing parameters**

<table>
<thead>
<tr>
<th>Processing regimes</th>
<th>Metal-Carbide type</th>
<th>current [A]</th>
<th>pulse period [µs]</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coarse</td>
<td>G40</td>
<td>25</td>
<td>95</td>
</tr>
<tr>
<td></td>
<td></td>
<td>50</td>
<td>95</td>
</tr>
<tr>
<td>Finishing</td>
<td></td>
<td>6.25</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>12.5</td>
<td>8</td>
</tr>
</tbody>
</table>

The samples were analyzed macroscopically with a stereo microscope. For the coarse regime the G40 type, which have a large quantity of binder and a lower hardness, shows an increase area for every crater with a flattening tendency of its shape (figures 3, 4, 5 and 6). For the toughest processing regime \((I = 50A, t_i = 95\mu s)\) a delimitation tendency of the bounding appears and an increase density of the fine composed particles over the processed surface (figures 5 and 6).

Starting from the fact that every material has a unique characteristic of stability during the EDM process, for the hard sintered alloys processing it can be observed a selective characteristic of the process, which shows the binder’s (Co) erosion with a lower stability than the carbide (CW).

For the finishing regime it can be observed an increase of crater’s depth after the pulse period of \(8\mu s\) and a current of 6.25A (figures 7 and 8, compared with figures 9 and 10).
The macroscopic examination of the processed surfaces shows that the material processing is realized through a discontinuous and cumulative process. The shape of the processed surfaces by EDM process is characterized by a complete isotropy comparing with the cutting process, which induce a preferential direction. The roughness and the orientation of the micro lattices of a processed surface by EDM process will be identical on all directions.

Some of the processed samples for the different working regimes have been transversal sectioned and analyzed by microscopic analysis.

After the WEDM processing on an ELEROFIL machine, the samples have been rectified on the surfaces needed to be prepared for the microscopic analysis then treated with a water-repellent metallographic paper with different granulations.

Next, the samples have been polished with a diamond paste, a special technique used for a cleaner surface then mechanical polished and chemical attacked with Murakami reactant and metallographic analyzed with an EpiTyp2 microscope.

It was proved the existence of a superficial surface layer affected by the EDM process, which increases its depth with the increasing of the values of the EDM processing parameters. This layer appears because of the melting process and the recrystallization process of the melted material remained inside the crater.

The interaction between the working medium and the processed material establishes, based on the microstructure shape, the modifications of the carbide nature in the superficial surface layer compared with the core material of the samples.

The coarse process revealed deeper layers than the finishing process, as showed in figure 11, compared with figure 12.

Exceeding certain values of the coarse processing lead to the appearance of tiny cracks into the margin layer, orthogonal oriented on the processed surface (figure 13), the arc ignition appear usually because of the existent pores into the hard sintered alloys.

During the finishing regime it was not found any defects like tiny cracks into the superficial surface layer of the processed samples (figure 12).

The depth of the tiny cracks will increase with the increase of the pulse period. During the 12µs pulse periods could not be detected any defect, not even at 1000 x magnification.

From the microstructure analyses results the thermal nature of the appearance of cracks into the sample’s material.

The electric discharge caused the heating of some portions of material from the surface layer, which tends to expand. This tendency is blocked by the cold layers of material. This way into the heated volume of material appears recompression strains. When the current pulses stops the heated material is cooled down by working space, which determines the volume’s decrease. Surrounding cold layers oppose this tendency and as result in the surface layer
appears stretching strains which break the binder determining the appearance of the cracks in the superficial surface layer. The stress values vary with the volume of the heated material. For large pulse periods, the volume of the heated material is large appearing distinct stresses and determining the cracks into the superficial surface layer. The dependence of the tiny cracks presence and the pulse period is determined by the proportion between the dimensions of the melting zone and vaporization zone of material under the influence of electric discharge. Long pulses lead to large melted areas, the heat propagating into a large volume of material. For short pulses the materials are processed mainly by a vaporization process, the heat didn’t have the time to propagate into the material and presenting a limited heating process in a small volume of material.

2. THE CONCLUSIONS
For the hard sintered alloys processing the mechanism of the material processing is influenced not only by the thermodynamic processes but also by the cracks in the superficial surface layer, which helps the detachment of solid particles. The shape of the processed surface, characterized by a complete isotropy, is determined by the applied working regime. The depth of the superficial surface layer depends also on the working regime. The depth of the cracked layer depends on the pulse energy, the most powerful influence having the pulse period.

BIBLIOGRAPHY