ANNALS of the ORADEA UNIVERSITY.
Fascicle of Management and Technological Engineering, Volume XI (XXI), 2012, NR2

EROSION COMPLEX PROCESSING ASSISTED BY ULTRASOUND I

Nioaţă Alin
University "Constantin Brâncuşi" of Târgu-Jiu, nalin@utgjiu

Keywords: erosion complex, ultrasounds, speed, electrode, work liquid.

Abstract: The hybrid methods of machining involve the integration of two or several different methods of machining in only one process able to exploit the individual advantages of the respective methods and to remove/diminish the possible negative effects/disadvantages specific to the respective methods. By applying a hybrid method of machining, we follow not only the reunion of the positive effects of the considered individual methods, but also the increase of some of these effects through synergetic action.

1. INTRODUCTION

The machining proceedings by means of electric and electrochemical complex erosion are a part of the category of hybrid machining proceedings whose appearance has been mainly determined by the individual disadvantages presented by some of the unconventional methods (for example, relatively small productivity of machining by means of electrochemical erosion, poor accuracy of machining by electric erosion, etc.) which have led to the search of certain means to exploit the advantages and to minimize the disadvantages registered in frame of certain machining on only one unconventional method.

Considering the weight of each process involved in changing the material of semi-fabricated products, the hybrid methods of machining are classified in:

- hybrid methods of machining where the involved processes develop simultaneously and both of them contribute directly to the removal of the material of the semi-fabricated product (for example, machining through complex, electric and electrochemical erosion);
- hybrid methods of machining in whose frame there is a process having the role to ease the development in better conditions of the other involved process (for example, machining through electrochemical erosion assisted by ultrasounds where the role of the ultrasonic vibrations presence is to stop the forming of a passivant layer on the surface of the semi-fabricated). When describing certain methods, it is difficult to establish which the main process is and which the secondary one is.

We should mention that the hybrid methods of machining based on combining a classic method of machining with an unconventional one (for example, lathing assisted by the laser beam) are also represented by some hybrid methods consisting in applying simultaneously two unconventional methods (for example, machining by complex, electric and electrochemical erosion) and by some hybrid methods unifying three different unconventional principles, such as machining by complex, electric and electrochemical erosion assisted by ultrasounds.

A machining method resulted from the combination of different electro-physical and electrochemical processes of machining offer new technological possibilities regarding the accuracy, the surface quality, the productivity etc. One of the most known and of the oldest hybrid methods of machining is constituted by the machining by complex, electric and electrochemical erosion which is based on processes of sampling material from the semi-fabricated both through electrochemical and electric means. These processes are developed at the same time, but they are differentiated in space. Theoretically, it is possible to accomplish a machining through complex, electric and electrochemical erosion assisted by ultrasounds due to the possibility of overlapping in time these three processes (electro-erosion, electrochemical dissolution and cavitation phenomenon)

2. POSSIBILITIES TO OBTAIN CERTAIN HYBRID METHODS OF MACHINING

Considering the physical-chemical phenomena interfering in their development, it is considered that the main unconventional technologies of machining are: EDM - electrical discharge machining, ECM - electrochemical machining, CM- chemical machining, laser beam machining – LBM), electron beam machining- EBM, water jet machining – WJM, ultrasonic machining – USM.

Table 1 presents some of the hybrid methods of machining obtained by combining two unconventional methods known in the special literature.

Thus, we may enumerate:

- ECDM - electrochemical discharge machining;
- USMEC - ultrasonic machining with electrochemical assistance;
- EDMLB – electric discharge machining with laser beam;
- EDMUS- electric discharge machining with ultrasounds, applied at the electrodes machining – the lead tool, when obtaining the micro-orifices, the slots or the complex cavitations. It is provided a better quality of the processed surface, with a thermally affected layer of a smaller thickness;
- ECMUS – electrochemical machining by electrochemical erosion with ultrasounds, supposing the use of an electrolytic liquid with abrasive particles in suspension providing both the anodic development of the semi-fabricated material and the appearance of the cavitation phenomenon, in the presence of the ultrasounds; this phenomenon stops the forming of the passivant layer;
- CMLB - chemical machining with laser beam;
- CMEB – chemical machining with electron beam (for example, electronolytographing);
- LBMWJ – laser beam machining with water jet;
- LBMUS – laser beam machining assisted by ultrasounds.

Table. 1. Possibilities of combining the unconventional machining in order to obtain some hybrid methods of machining

Unconventional methods of machining	EDM	ECM	CM	USM	LBM	EBM	WJM
EDM	*	ECDM	?	USMED	LBMED	?	?
ECM	EDECM	*	X	USMEC	LBECM	?	?
CM	?	X	*	USCM	LBCM	EBCM	?
USM	EDMUS	ECMUS	CMUS	*	LBMUS	?	?
LBM	EDMLB	ECMLB	CMLB	?	*	?	?
EBM	?	?	CMEB	?	?	*	?
WJM	?	?	?	?	LBMWJ	?	*

In table 1, we have used the symbol (*) for the senseless combinations (being about the same machining method); the X symbol for the situations when the combination of two methods supposes the development of one of them – for example, ECM + CM → ECM. For those hybrid methods susceptible of applied, but about which we have no information regarding their materialization until present, we have used the symbol (?).

We expect the appearance and the application of new hybrid methods of machining in the next decades.

3. THE POSSIBILITY TO APPLY A MACHINING BY COMPLEX, ELECTRIC AND ELECTROCHEMICAL EROSION ASSISTED BY ULTRASOUNDS

The machining through complex, electric and electrochemical erosion assisted by ultrasounds may be considered as a new machining method.

The machining by complex, electric and electrochemical erosion involves the simultaneous development of two different processes, respectively electric erosion (by unleashing the electric discharges) and an anodic dissolution of the material of the semi-fabricated. Usually, the tool-electrode is connected to the cathode and the semi-fabricated, to the anode. That anodic dissolution is due tot he properties of the electrolyte and to the presence of electricity. Depending on the type of the electrolyte (which can be a semidielectric, a passivant or not passivant electrolyte), during the machining process there may be formed a passivant layer on the surface of the semi-fabricated. This layer determines a diminution of the electrochemical dissolution of the material of the semi-fabricated, and in certain situations this process is completely stopped.

The machining technologies assisted by ultrasounds are based on the presence of some high frequency vibrations (the ultrasonic vibrations have a frequency higher than 20 kHz).

The presence of the ultrasounds in the environment of the work liquid determine the so-called cavitation phenomenon consisting in breaking the liquid mass in microscopic spheres for a very short time. At the immediate recovery of the mass integrity of the liquid, there are reached high values of the local temperature and pressure. These local changes of temperature and pressure produce micro-breaks in the material of the semi-fabricated, micro-breaks that determine an additional sampling of the material on the surface of the semi-fabricated.

The researches accomplished in this field show that, at the level of the spheres appeared in the cavitation phenomenon, there are generated small electric discharges; as a consequence of the electric discharges in the liquid environment, there were noticed certain chemical reactions such as oxidations, polymerizations, depolymerizations, syntheses etc. It is expected for the presence of the ultrasounds at a machining by complex, electric and electrochemical erosion to intensify certain chemical reactions or even to generate new ones.

For example, as an effect of propagating the ultrasounds by means of a water quantity, there may appear some ionic structures: $H_2O - e = H_2O^+ = H^+ + HO$

From our viewpoint, it is important for the hydroxyl group OH to be able to react with the material of the semi-fabricated, determining thus an increase of its sampling speed.

The ultrasonic field created in the machining area will diminish the chances of forming the passivant layer. Due to the ultrasonic vibrations, the already dissolved particles of the material of the semi-fabricate will be easier to remove from the working interstitium as the passivant layer does not have a continuous feature. It is expected at the unleashing of the electric discharges between the tops of the asperities on the cathode (electrode-tool) and anode (electrode-piece), in conditions of the ultrasonic vibration either of the electrode-tool, or of the semi-fabricated, to register an amplification of the micro-breaks propagation.

On the other hand, by applying ultrasonic vibrations to the work liquid, the metallic particles appeared as a consequence of the electric discharges or even of the presence of the ultrasounds, may be easier to detach from the surface of the semi-fabricated.

Theoretically, it has been proved that the sampling speed of the material of the semi-fabricated may be estimated according to a relation such as:

$$v = \frac{\frac{a}{NF}\left|U_{om}\sin\omega_2 t\right|k_\theta A}{S_{Fe}\rho_a} \qquad (1)$$

where: F is Faraday's number, F=96.500 As, U_{om} is the maximum amplitude of the tension, ω_2 is the angular speed, t-time, k_θ is the electrolyte conductivity, A is the area of the active surface of the electrode-tool, S_{Fe} is the balance value of the interstitium size, and ρ_a is the density of the material of the semi-fabricated.

In the field of machining by complex, electric and electrochemical erosion, the current research directions are: D1- machining the isolating materials; D2 – enlarging the scale of the used work liquids; D3 – using the method of the finite element in order to calculate the temperature distribution; D4 – theoretical modelling of the device of sampling the material; D5 – extending the application of the machining method by complex, electric and electrochemical erosion, and in frame of a rectifying procedure; D6 – imposing certain additional movements to one or to both of the electrodes; D7 – creating certain equipments that should allow the accomplishment of certain machining both by electro-erosion and by electrochemical erosion of ultrasounds. Following the steps specific to the method of value analysis, by the technique of the imposed decision, there were calculated the importance coefficients of each criterion, then there were determined the value numbers corresponding to the constructive solutions analysed for every criterion. After this analysis, it results that the main research direction in the field of machining by complex, electric and electrochemical erosion, the order of the research direction is D1 – machining the isolating materials (such as ceramics, glass, composite materials), followed by D4 – theoretical modelling of the device of sampling the material, by using the method of the finite element in order to calculate the temperature distribution (D3), enlarging the scale of the used work liquids (D2), D6 – imposing certain additional movements to one or to both of the electrodes, D5 – extending the application of the machining method by complex, electric and electrochemical erosion, and in frame of a rectification procedure and D7 – creating certain equipments that should allow the accomplishment of certain machining both by electro-erosion and by electrochemical erosion or even by complex, electric and electrochemical erosion assisted by ultrasounds, being rarely found in the special literature.

References:

[1] Amza, Gh. – Sisteme ultraacustice, Editura Tehnică, Bucureşti, 1989.
[2] Amza, Gh. şi Dobrotă, D. - Ultrasunetele. Aplicaţii active, Editura AGIR, Bucureşti, 2007.
[3] Brojboiu, M. – Electrotehnologii, Editura Orizonturi Universitare, Timişoara, 2002.
[4] Herman, R.I.E., ş.a. – Prelucrarea prin eroziune complexă electrică- electrochimică, Editura Augusta, Timişoara, 2004.
[5] Nagîţ, Gh., - Tehnologii neconvenţionale, Universitatea Tehnică „Gh. Asachi", Iaşi, 1998.
[6] Nagy, I. – Ultrasunetele şi utilizarea lor, Editura Ştiinţifică şi Enciclopedică, Bucureşti, 1982
[7] Nioaţă, A. – Cercetări teoretice şi experimentale privind optimizarea unor parametri ai prelucrării prin eroziune complexă, Teză de doctorat, Sibiu, iulie 2007.
[8] Paicu, G. – Tehnologii electrice speciale, Casa de Editură Venus, Iaşi, 2006.
[9] Popescu, C. L. şi Popescu, M. O. – Electrotehnologii – principii şi aplicaţii, Editura MATRIXROM, Bucureşti, 1997.