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A NEW HYBRID MACHINING TECHNOLOGIES

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Abstract: *We are expecting to introduce a new equipement that will combine the benefits of the Die Sinking Electrical Discharge Machining with one that will use Ultrasonic Machining. If both parts will work simultaneously we will have a new hybrid technology. In the same time, both parts can work independently as either a Die Sinking Electrical Discharge Machining or as a Ultrasonic Machining.*

Key words: *hybrid machining, electrical discharge machining, ultrasonic machining, Barkhausen phenomenon, nonconventional processes.*

1. INTRODUCTION

The objective of our research project is to design and build a new equipement for new nonconventional hybrid technology that will combine Die Sinking Electrical Discharge Machining with Ultrasonic Machining. This new type of instrument will open the possibility of research in the field of machining by monitoring surface quality, morphological changes in the outmost layers, the depth of the modifications, and the cost of the machining [1].

The Laboratory at INSA-Lyon, France will analyze the nanostructure of the samples through non-destructive methods based on Barkhausen phenomenon.

The research group at National Institute of Technical Physics will supply the equipment for Ultrasonic Machining.

By using this new hybrid technology, the Ultrasonic oscillations will allow an increase in the speed of processing through the cavitations effects, and the microcracking of the outer most surface layer of the part that requires machining. We believe that this process will also improve the quality of the processed part by reducing the lateral gap and by creating a higher surface quality [2].

Unconventional technologies were born in fifth decade of the XX century as a natural evolution of the manufacturing technologies development and the turn up of the materials with higher mechanical properties. This was possible as a result of the application of relatively new theories, for that period of time, from the physics domain and inner structures of the matter. One turn up an important number of unconventional technologies manufacturing process, among them electrical discharge machining. As well as the other unconventional technologies, the electrical discharge machining has a spectacular evolution together with the new discovers and achievements in electronic domain.

2. THE ELECTRICAL DISCHARGE – ULTRASONIC HYBRID MACHINING EQUIPMENT

The basic structure of the hybrid machining equipment (Fig. 1) is obtained by mounting the ultrasonic equipment

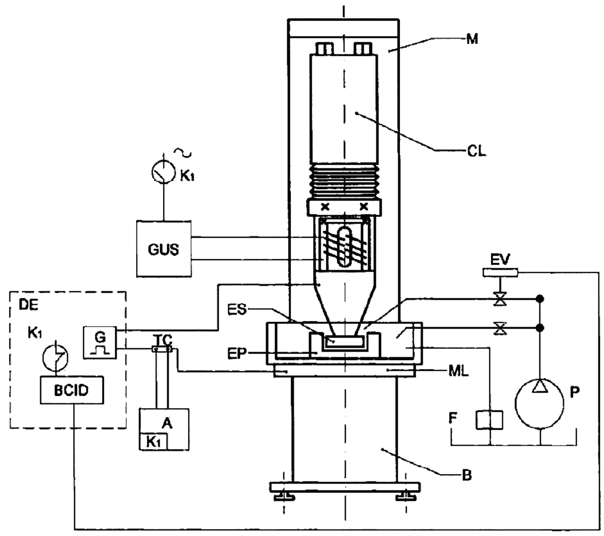

Fig. 1. Electrical discharge-ultrasonic machining equipment.

on the working head (*CL*) of an electrical discharge machine tool (*M*) [3].

The work-piece, working electrode (*EP*), is mounted on the machine tool table (*ML*), while the tool electrode (*ES*) is fixed on the ultrasonic vibration amplifier connected to the ultrasonic generator (*GUS*).

An automatic electrical installation (*A*), command through the (K_1) contact the starting of the (*GUS*) generator in total concordance with the impulse given by the (*G*) generator of the electrical discharge machine tool; in order to determine the impulses from the (*G*) generator on use an electrical current transducer (*TC*). Also, through the (K_1) contact one command the washing installation formed by the command block (*BC*1*D*) and electro-valve (*EV*) which connect the pump (*P*) by the machine tool watt were are immersed in dielectric liquid the work-piece and the tool electrode.

The machining equipment is made in the Fine Mechanics Laboratory, "Gh. Asachi" Technical University, Iaşi, Romania. From the figure one can observe the way in which it was combined the two machining equipments – the electrical discharge machining equipments and the ultra-acoustic oscillation machining equipments. On mount on the ELER 01 GEP-50 F machine type structure the ultra-acoustic equipment (with frequency of 28 kHz and the power of 400W) [4].

The high complexity of the electrical discharge manufacturing process and the ultra-acoustic process, due to a great number of factors, rise the manufacturing cell adjustments in comparison with an objective function, such as the manufacturing productivity. Among other, this parameter is function of the tool electrode speed which can be determined with the following relation:

$$\mathrm{d}V_S/\mathrm{d}I_m. \quad (1)$$

in comparison with time one obtain:

$$\mathrm{d}V_s/\mathrm{d}t \quad \text{and} \quad \mathrm{d}I_m/\mathrm{d}t. \quad (2)$$

but these elements are hard to control and even hard to express (mathematical), that is why one consider other elements of the manufacturing process, taking into account their extreme values between which the manufacturing process parameters must varies. In this way the manufacturing productivity can be evaluated based on indirect criteria such as the ratio between effective impulse number and fictitious impulse number or the delay from the launching of the potential impulse and the appearing of the current in working space. In this case, one considers optimum working conditions, for a given situation, when the number of fictitious impulse number is minimum.

The distance between electrodes in the idle running impulse case must be shorten and in the short circuit case must be increased. The manufacturing optimum regime must be situated between these two extreme situations and the number of the working impulse must have maximum value from the total number of impulses.

In the case of the potential impulse one exist an certain maximum value of the potential which must not be exceed and for the current impulse a certain time which determine the impulse size. The optimum working regime must be situated among above mentioned limits. In Fig. 2 on distinguish: 1 and 2 blocks for the current impulse initiation; 3 – logical circuit; 4 and 5 – blocks of the potential impulse initiation; 6 – fictitious impulse detector; 7 – workmanship element; 8 – automat potentiometer; 9 – feed self-regulator.

In the case of full potential signal one have only current signal and this means short circuit situation and the logical circuit 3 will send a signal of removing the electrodes. In the case of null current signal one have just potential signal. This means that one have a great distance between electrodes, logical circuit 3 will sent a signal for approaching the electrodes.

The optimum working regime is obtained when it exist both potential and current signals. In this period one the fictitious impulse detector 6 is present by approaching the electrodes.

In order to utilize the value of the command and optimization scheme of the EDMUS manufacturing process (Fig. 3) is useful to present the relation between the EDMUS working cycle possible impulse types. In Fig. 3 one distinguish the *CCAA* – command head of the vertical feed; *GOUAS* – ultra-acoustic oscillation generator; *GI* – electrical discharge impulse generator; *BC* – command block

$$F_i = f_P + f_M + f_G + f_{SC} + f_o, \quad (3)$$

where: f_i – impulse frequency; f_P – sampling impulse frequency; f_M – crumbling impulse frequency; f_G – fictitious impulse frequency in working zone (*ML*); f_{SC} – short circuit impulse frequency; f_o – idle running impulse frequency.

The sampling impulse frequency has a primary sampling impulse component – f_{PP} and *a* a sampling and crumbling impulse component – f_{PM} with a sampling efficiency η

$$F_P = f_{PP} + \eta\, f_{PM}, \quad (4)$$

f_M will be:

$$F_M = f_{SM} + (1 - \eta)\, f_{PM}, \quad (5)$$

where f_{SM} is the crumbling joint impulse at the f_{SM} frequency of secondary impulses of pure crumbling.

The first machining trial with the new equipment is encouraging. One find a meaningful decreasing of the

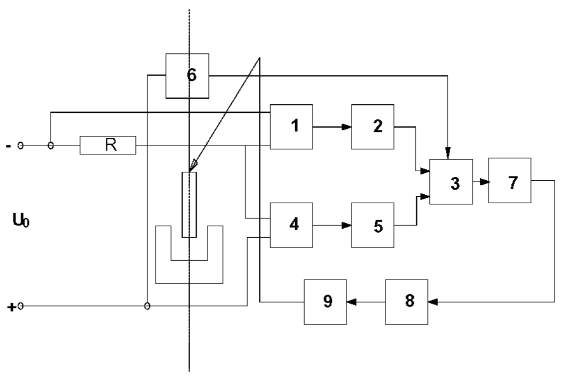

Fig. 2. Block diagram of commands.

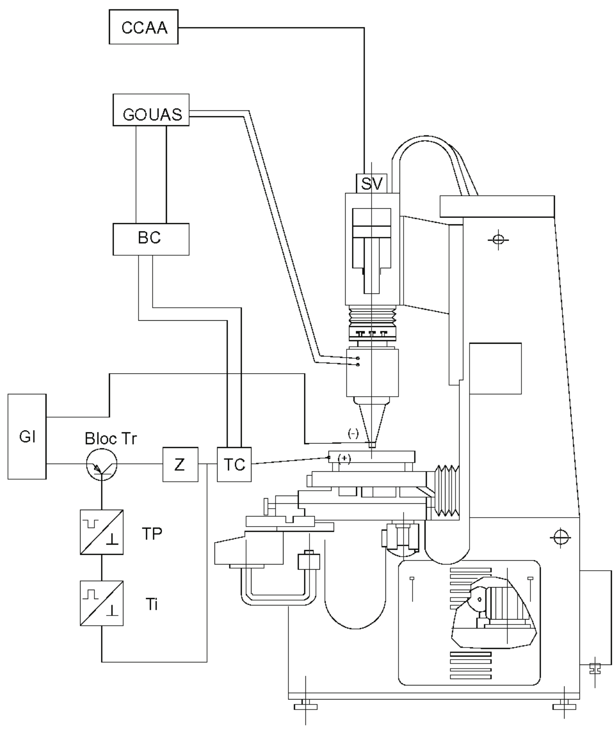

Fig. 3. Equipment for hybrid machining.

machining time for the bore with diameter of 5 mm and plate thickness of 5 mm.

These two machining types combination (Electrical Discharge Machining with Ultrasonic Assistance-EDMUS) had a series of consequences, most of them favorable, upon the machining technologies, working parameters, the quality of the machined surface, in a word, upon the technical and economical performance. The ultra-acoustic oscillation is overlap on the electrical discharge process which leads to benefit effects in machining through the cavity phenomenon. Thus on improve the washing conditions in working zone and one accelerated the matter sampling process from the erosion crater. These elements are decisive in small dimensions boring and cross line network [5].

The tool-electrode or work-piece ultra-acoustic oscillation movement accelerated the elimination of the micro-granular detached in the machining process and increase the pumping phenomenon; one eliminated the contaminated dielectric and the clean dielectric come in fast, facilitating a new series of discharges, thus increasing their efficiency and the sampling speed.

The second benefit in the ultra-acoustic discharge machining is bounded to the machined matter structural modification. The alternate movement of the tool-electrode with high frequency given by the ultra-acoustic oscillation amplifies the turbulence and cavity phenomena which have as result an efficient ejection of the electrical discharge machining products from the working zone.

The machining parameters were watching with the help of an oscilloscope, PICOSCOP type (England) using a scheme presented in Fig. 4.

In Figs. 5 and 6 one presents two of the oscillograms showing the evolution of the electrical discharges in working zone, using an ED classical process and the new process called EDMUS.

The hybrid manufacturing process, named EDMUS (Electro Discharge Machining and Ultrasonic Machining) bring an uniformity of the electrical discharges by modifying the discharge conditions between the electrodes. One can observe from Fig. 5, after a discharge zone through an simple ED process which include both *A*1 and *A*2 zones (the starting of the discharge is not started), a zone where for an interval of 358 microseconds one determine a discharge frequency of 27 discharge per second in which all discharges are with material removal. If one define an filling coefficient as the ratio between the removal discharges f_P and the total number of discharges f_i, one can determine that one have maximum value on this interval and in command scheme (Fig. 2) one have maximum productivity.

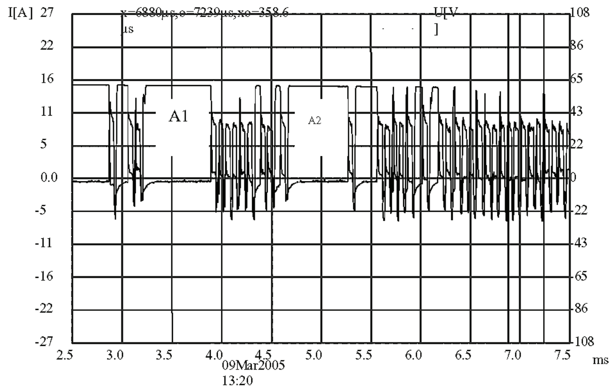

Fig. 5. Series of discharges – classic procedure ED (first level of power).

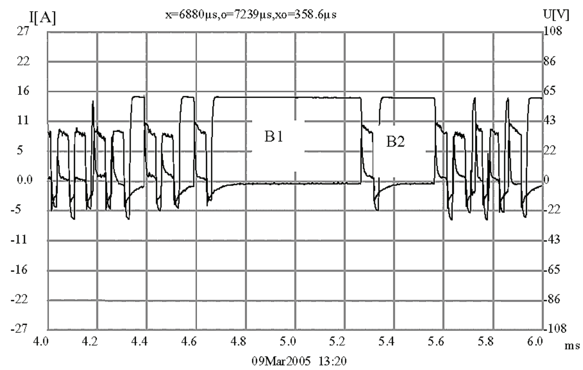

Fig. 6. Series of discharges-EDMUS procedure.

In Fig. 6 one considers an EDM type discharging zone where *B*1 and *B*2 zones are discharges without starting. For these one do not establish optimum conditions for brake off the space between the electrodes and the machine tool is idle running. The productivity is reduced and the electrical energy consumption is high. As soon as the EDMUS start one determine, after 5,6 microseconds, a calm down of the electrical discharge between the electrodes, maintaining the value of the starting potential in time, and a constant discharge current. Also one has a positive effect of the discharge energy which assures a uniform quality of the manufactured surface.

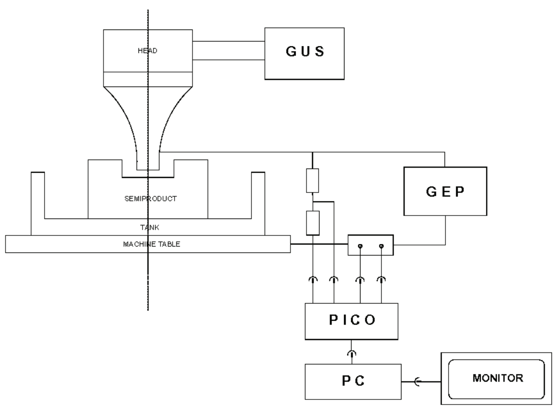

Fig. 4. Equipment for measuring of technological parameter.

3. CONCLUSION

The attempt of association of two unconventional machining processes – electrical discharge machining and ultra acoustic oscillation machining – could be materialized using new machining equipment which is called hybrid machining technology. The equipment are relatively simple to handle and can be used separately or together. These two classical machining technologies do not give birth to a new unconventional technology. Their separate action could be easily emphasized but working together one could observe an improving of the technological performance through much better working conditions given by those two processes, one for the other. The present paper aim to present such an achievement obtained in the Fine Mechanics Department, “Gh. Asachi” Technical University, Iaşi, Romania.

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