A GEOGEBRA APPROACH OF THE COMPLEX EROSION MODELING

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ABSTRACT: More emphasized while the technology developed in the last years, some category of materials are difficult to process by regular techniques (requiring high energy, special conditions or high quality tools), but nowadays there can be processed at lower costs using nonconventional technologies. At once, using computer programs in correlation with the technological process increases the accuracy of results and reduces the processing time. These computer programs can be designed to assist the human operator at the processing using al kind of technologies, including the nonconventional methods (as the complex electric-electrochemical erosion – named also the complex erosion). After collecting data from a database, containing all experimental results, the program computes a modeling of the process and etsblish the optimum process parameters.

KEYWORDS: complex erosion, complex electrical and electrochemical erosion, software modeling, GeoGebra.

1. INTRODUCTION

The complex electrical and electrochemical erosion is preferred to other conventional methods where the processed object (PO) is made of a very difficult to process material, as special steels, diverse stainless alloys, etc.

Technological, the complex erosion is characterized by the overlapping in space in time of two conventional processing procedures: the electric erosion and electro-chemical erosion, with mechanic depassivation ([Kar04]). Regarding the physic and chemical processes, this nonconventional method is a superposition of a, mechanic and an electric process, simultaneously applied in the working space (WS):

- because of the PO and of the transfer object (TO) connection to a source of continuous current, an electric field E appears between the two electrodes, leading to the emergence of a substance transportation (due to the chemical reactions) from the liquid working environment (WE) in which the processing takes place and on the PO surface;
- when the film laid down on the OT surface gets a certain thickness, the PO chemical dissolving process stops;
- because of the PO dislocation towards TO and of the contact pressure between the electrodes, the film is removed and the two pieces come in contact;
- the electrical discharges in impulse occur, melting and vaporizing the PO surface;
- the newly appeared craters on the PO surface permit the restarting of the processing process.

Among the electrical, mechanical, environmental factors influencing the results of the complex electrical erosion processing, the induced power in the working space have a big influence. So, apparently, maximizing productivity could be done by increasing the introduced power in the WS. But, experimentally ([Her95, Kar04]), there has been determined that the increasing of the tension over 30V and of the current over 100A leads to the instability of the process and to unexpected bad results (productivity, the quality of the surface).

The instability can be explain by the existence of a certain current density, which, when surpassed, makes the electrical discharges between electrodes turn from the impulse phase to the one of an electrical arch, hard to control, with huge material extractions from the PO surface and rapid TO degradation.

Establishing a mathematical function to indicate the dependency between the processing time and the induced power P in WS, it becomes possible to determine which is the optimal processing time of a PO having certain characteristics (material, shape, thickness, etc), in certain working conditions (the induced power P – in this paper). Once this formula determined, its checking by experimental attempts is the next step and, if confirmed, it can be used for setting up the optimal processing area in which minimal processing time is obtained, in the conditions of economical energetic consumption.

2. DEBITING TIME OPTIMIZATION USING MATHEMATICAL MODELING

In this paper, we intend to determine the mathematical pattern of the dependency between the processing time t and the induced power P.

Therefore, we analyzed some debiting experiments of PO samples in different electrical conditions (U, I, R, L, C) ([NL86]).

The results are presented below in the table 1.

Table 1. The experimental results of the debiting time

Instance A: R=0.188 Ω, L=8.5 mH, C=0 μF				Instance B: R=0 Ω, L=0 mH, C=0 μF				Instance C: R=0.047 Ω, L=0 mH, C=0 μF			
U [V]	I [A]	P [W]	t_p [s]	U [V]	I [A]	P [W]	t_p [s]	U [V]	I [A]	P [W]	t_p [s]
15	50	750	600	15.8	30	474	630	34	100	3400	215
18		900	490	15.5	50	775	360	32.4	150	4860	185
20		1000	400	23.5	100	2350	170	29.5	50	5900	360
21		1050	395	23	150	3450	105	31	200	6200	120
22		1100	380	22.5	200	4500	40				
25		1250	390								
27		1350	365								
31		1550	400								

Table 2. The calculated results of the debiting time

Instance A: R=0.188 Ω, L=8.5 mH, C=0 μF			Instance B: R=0 Ω, L=0 mH, C=0 μF			Instance C: R=0.047 Ω, L=0 mH, C=0 μF		
P [W]	$t_{calculus}$ [s]	Error [s]	P [W]	$t_{calculus}$ [s]	Error [s]	P [W]	$t_{calculus}$ [s]	Error [s]
750	604	4	474	584	46	3400	215	0
900	470	20	775	426	66	4860	185	0
1000	416	16	2350	126	44	5900	360	0
1050	398	3	3450	139	34	6200	120	0
1100	385	5	4500	30	10			
1250	370	20						
1350	375	10						
1550	399	1						

Based on these previous researches (especially [Her95]), we start to calculate a mathematical pattern of the dependency, using first, second and third polynomial functions:

$$t_1 = f_1(P) = a_1 * P + a_0 \quad (1)$$

$$t_2 = f_2(P) = a_2 * P^2 + a_1 * P + a_0 \quad (2)$$

$$t_3 = f_3(P) = a_3 * P^3 + a_2 * P^2 + a_1 * P + a_0 \quad (3)$$

where:

- t denotes the processing time
- P denotes the induced power
- $a_3, \ldots, a_0$ denote the unknown coefficients

The most common method to compute the $a_3, \ldots, a_0$ coefficients is the approximation method of least squares (best referenced in [Kil97]).

For the three instances from table 1, the values were obtained using a computer program, ([Kar06, Kar07]).

For all three experiments, the best approximation (or the minimum errors) occurred if the third rank polynomial function is applied, so the best matching presents the following dependencies:

$$t_3 = -7.7901*10^{-7}*P^3 + 3.4704*10^{-3}*P^2 - 5.02258*P + 2.7477*10^3 \quad (4)$$

$$t_3 = -3.46646*10^{-8}*P^3 + 3.0365*10^{-4}*P^2 - 8.64095*10^{-1}*P + 9.29158*10^2 \quad (5)$$

$$t_3 = -2.85041*10^{-7}*P^3 + 4.11171*10^{-3}*P^2 - 1.92456*10^1*P + 2.9322*10^4 \quad (6)$$

where the three time-functions correspond to the A, B respectively C electrical conditions.

The graphical representation of the t_3 functions, experimentally respectively theoretically determined, is presented in the figures 1-3 (where fit(P) represents the interpolation function, and f(P) represents the optimal determined 3rd rank functions).

In the table 2, the calculated processing time bases on the (4) – (6) functions presented below. The error is expressed as the difference between the experimental values and the calculated ones, based on the best fitting functions (4)-(6).

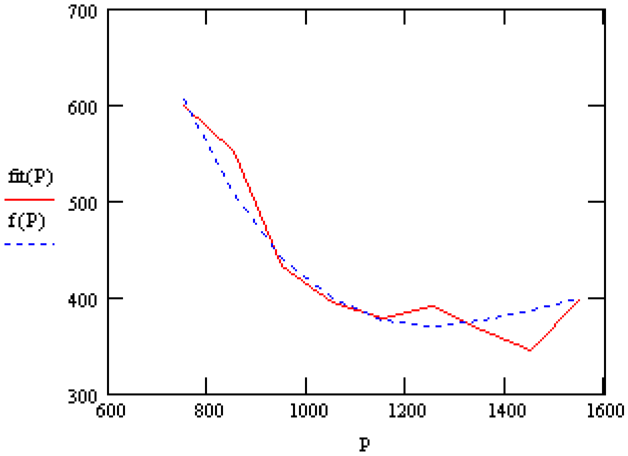

Fig. 1. Graphical MathCAD representation for instance A

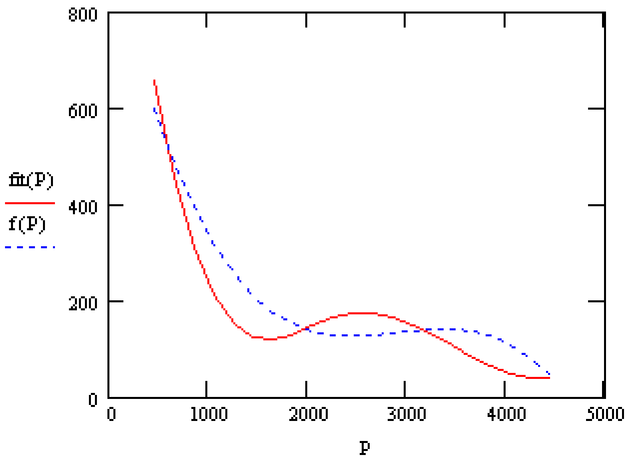

Fig. 2. Graphical MathCAD representation for instance B

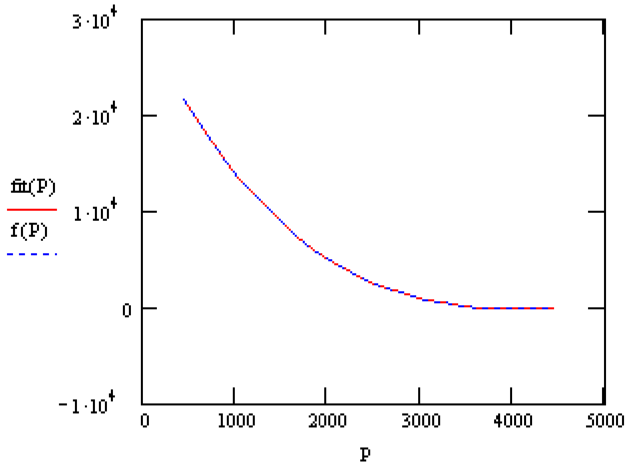

Fig. 3. Graphical MathCAD representation for instance C

Note that the errors does not surpass 10% so the determined pattern is correct and can be used as a model for processing time dependency on the induced power in the WS.

3. DEBITING TIME OPTIMIZATION USING GEOGEBRA

A mathematical software solution may be implemented in order to obtain quickly a better precision with low cost computing effort for the t=f(P) pattern. To solve this task, we used GeoGebra ([***12]), a new and free-to-use instrument for mathematical and statistical calculus. The main goal of the application is to link this computer program to an expert system which determines the optimal debiting conditions of the materials which accept the processing through complex electric-electrochemical erosion, using a selection from the database containing data on similar experiments.

Starting with the same input data as presented in the above examples, we obtained three frames presenting the optimum functions (similar to (4)-(6)) as presented in figures 4, 5 respectively 6.

Note that the best matching presents the following dependencies:

$$t_3 = -5.02 * P + 2747.7 \qquad (7)$$

$$t_3 = -0.86 * P + 929.16 \qquad (8)$$

$$t_3 = -19.25 * P + 29321.99 \qquad (9)$$

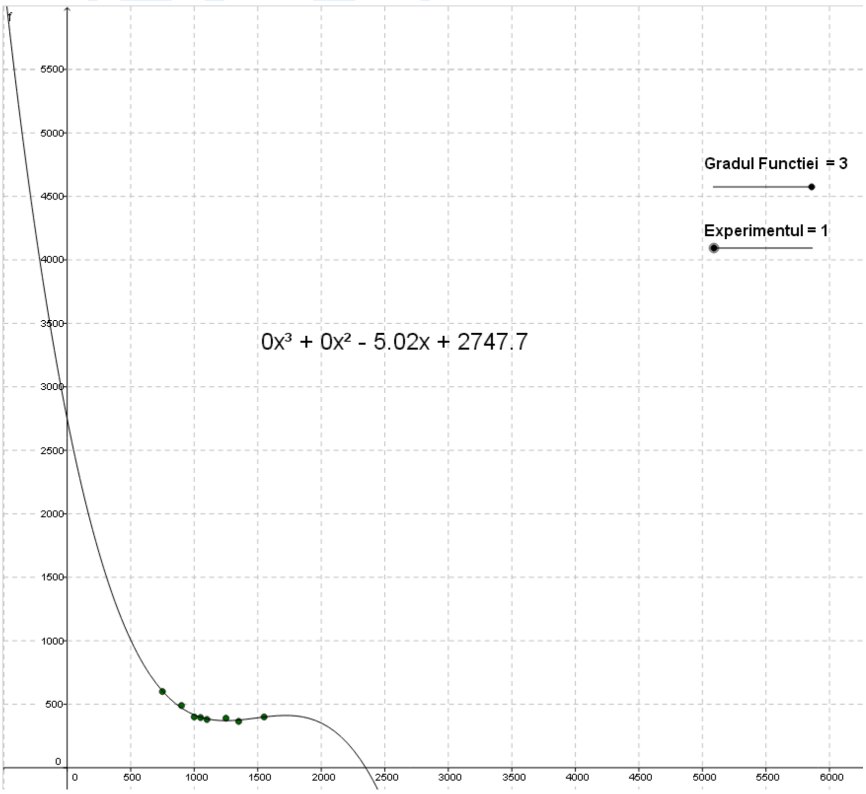

Fig. 4. Graphical GeoGebra representation of t=f(P) for instance A

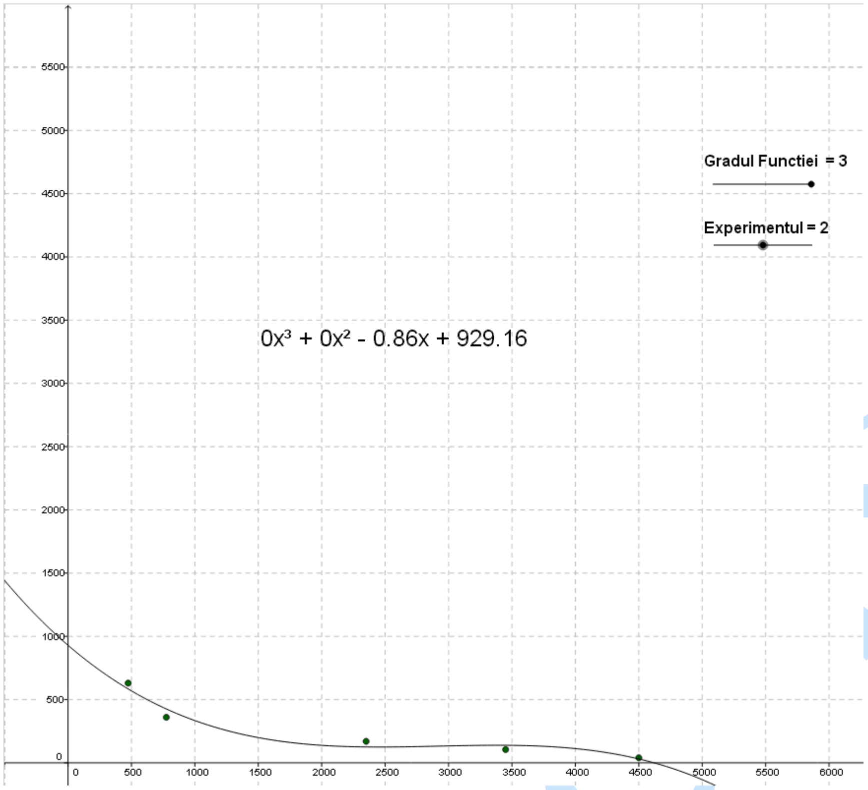

Fig. 5. Graphical GeoGebra representation of t=f(P) for instance B

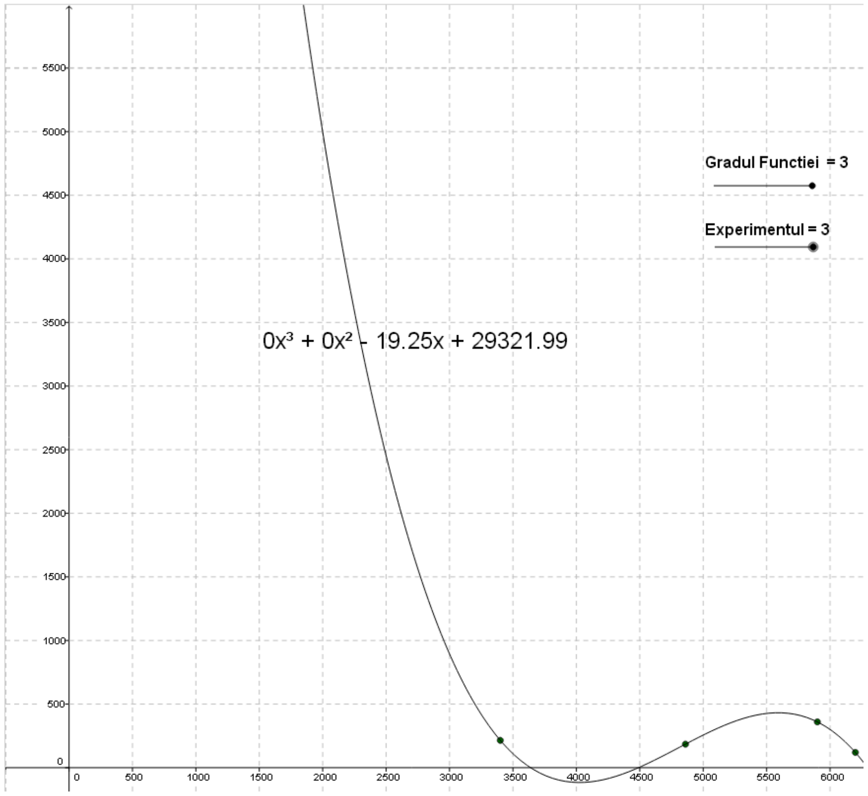

Fig. 6. Graphical GeoGebra representation of t=f(P) for instance C

We can now resume the coefficients a_3, ..., a_0 determined by both less square and GeoGebra methods (see table 3) and, as we can see, the values are comparable so both methods offer same results – this is a prove that our hypothesis is correct and the 3rd polynomial function is a (very) good approximation for the dependency t=f(P).

Table 3. Coefficient comparison

Coefficient	Method 1	Method 2
Instance A		
a_3	$-7.7901*10^{-7}$	0
a_2	$3.4704*10^{-3}$	0
a_1	-5.02258	5.02
a_0	$2.7477*10^{3}$	2747.7
Instance B		
a_3	$-3.46646*10^{-8}$	0
a_2	$3.0365*10^{-4}$	0
a_1	$-8.64095*10^{-1}$	-0.86
a_0	$9.29158*10^{2}$	929.16
Instance C		
a_3	$-2.85041*10^{-7}$	0
a_2	$4.11171*10^{-3}$	0
a_1	$-1.29456*10^{1}$	-19.25
a_0	$2.9322*10^{4}$	29321.99

4. CONCLUSIONS

Starting from the (4)-(6) and (7)-(9) functions, we can conclude that the polynomial functions are a good estimation of the dependency between the debiting time and the electrical power used for the debiting process.

At the same time, it's almost obvious that the optimum modeling polynomial functions – at least in the analyzed example – is the 3rd rank polynomial. But, as long as the coefficient a_3 of the polynomial is near zero, the 3rd rank reduces to an approximation of 2nd rank.

Generalizing the presented instruments in the debiting through nonconventional procedure, it makes the user able to know the optimum working conditions and the specific consumptions, which determines the selection of the optimal values of the process parameters. This result had a positive influence on manufacturing, on materials and energy, and reveals the advantages and the benefits of using the complex erosion method, in particular processing requirements.

Moreover, the benefits of using particular conditions for the processing parameters, generated by an optimization technique, may reflect on all king of technological processing, whether classic or nonconventional ones.

REFERENCES

[Her95] Herman R. - *Contribuţii la optimizarea realizării fantelor prin eroziune electrică complexă*, Teză de doctorat, Universitatea Tehnică din Timişoara, 1995.

[Kar04] Karnyanszky T. M. - *Contribuţii la conducerea automată a prelucrării dimensionale prin eroziune electrică complexă*, Teză de doctorat, Universitatea "Politehnica" Timişoara, 2004.

[Kar06] Karnyanszky T. M. - *Database Model for the Optimisation of the Processing by Unconventional Methods*, Buletinul Institutului Politehnic din Iaşi, Tomul LII (LVI), fasc. 5C, Iasi, 2006.

[Kar07] Karnyanszky T. M. - *Optimal Debiting using the Computer-Aided Compelx Erosion*, Nonconventional Technologies Review No. 2/2007, pp. 47-52

[Kil97] Kilyeni Şt. - *Metode numerice*, Editura Orizonturi Universitare, Timişoara, 1997.

[NL86] Nanu A., Lăncrăngean Z. - *Dependenţa caracteristicilor tehnologice de structura circuitului electric în cazul prelucrării prin eroziune electrică complexă*, în Academia RSR – *Tehnologiile neconvenţionale, mijloc de ridicare a eficienţei tehnico-economice în construcţia de maşini*, Simpozion Timişoara, 1986.

[***12] http://wiki.geogebra.org/en/Tutorial%3AMain_Page, accessed Nov 2013