NEW MATHEMATICAL SOFTWARE APPLIED TO NEW TECHNOLOGIES

Tiberiu Mariu Karnyanszky, Alexandra Emilia Fortiş

„Tibiscus" University of Timişoara-Romania, Faculty of Computers and Applied Computer Science

Abstract: Some techological materials are difficult to manufacture using regular processing techniques, so nowadays they can be manufactured using nonconventional technologies. Associating the new technologies with the usage of the computers, we can increase the accuracy of results, reduce the processing time, and/or improve the quality of the final product. Some computer applications or computer software can be used to increase the performances and the productivity of the technological processing, simultaneously with the reducing of the execution time or of the energy consumption. This new software can manage the whole technological proces or can be used to assist the human operator during the processing time. If the new software is to be used concurrent with a nonconventional method, the results are better revealed.

This paper presents an expert system which manage a cutting-machine, using the complex electric-electro-chemical erosion. The program collects data from a database, makes an optimization of the process using a new mathematical software – GeoGebra, and, finally offers the best combination of input parameters to obtain the best processing time.

Key words: cutting time optimization, electric-electrochemical erosion, software optimization, GeoGebra

1. INTRODUCTION

The complex electric-electrochemical erosion is nowadays preferred to cut materials very difficult to process as special steels, stainless alloys, carbides etc.

The complex electric-electrochemical erosion is defined by the overlapping of the two classic processing techniques: the electric erosion and the electro-chemical erosion, simultaneously with mechanic depassivation (as defined in [Her95, Kar04]). At the same time, in the working space (WS) are present a physic-chemic, a mechanic and an electric process:

- because the processed object (PO) and the transfer object (TO) are connected to a source of continuous current, an electric field (E) appears between the two electrodes. While both electrodes are emerged into a liquid working environment (WE), due to some chemical reactions, a substance transportation is made on the PO surface;
- when the film laid down on the OT surface gets a certain thickness, the PO chemical dissolving process stops;
- caused by the PO dislocation towards TO and by the contact pressure (p) between the electrodes, the film is removed and the two electrodes are in contact;
- electrical discharges in impulse occur, melting and vaporizing the PO surface;
- the newly appeared craters on the PO surface provide the restarting of the whole process.

Previous papers ([Kar04, Kar06, Kar07]) demonstrates that among the electrical, mechanical and the environmental factors influencing the results of the electric-electrochemical erosion processing, the induced power in the WS has an important influence.

Once established a mathematical function which indicates the dependency between the results (processing time, surface quality) and the input parameters (as the induced power P), it becomes possible to select which is the optimal processing time (in this paper) of a PO having certain characteristics (material, shape, thickness, a.s.o.), in certain working conditions like the induced power P. Once this formula is determined, it can be used for setting up the optimal processing area in which minimal processing time is obtained, in the conditions of minimal energetic consumption.

But the obtaining of the mathematical function is not even necessary: if we get the optimum induced power P, providing the minimum processing time t, automatically calculated by the pre-existing data from the database, the optimization process ensure the minimum consumption.

2. CUTTING TIME OPTIMIZATION USING CLASSIC METHODS

To determine the mathematical pattern of the processing time t by the induced power P, there were developed some cutting experiments of PO with the thickness of 45, 50 and 65 mm, in a solution of soluble sodium silicate, with M=3 and ρ=1,25 kg/dm^3, with the TO of 1,5 mm thickness and advance speed of 25m/s. The experimental results are displayed in the tables 1-3.

Based on these experimental results presented in ([Kar07, NL86), the next step is to compute the mathematical pattern of the dependency, using first, second and third polynomial function (as [H+99, Kar04] suggested), using the approximation method of least squares ([Kil97]):

$$t = f(P) = a_1 * P + a_0 \quad (1)$$

$$t = f(P) = a_2 * P^2 + a_1 * P + a_0 \quad (2)$$

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

where:

t the processing time
P the induced power in WP
$a_3, \ldots, a_0$ the determined coefficients

For the PO diameters taken into account we obtained the following results, presented as experimental (practically determined), and theoretical (computed using the best mathematical function) [Kar06, Kar07] in Table 1 to Table 3.

For all three experiments, the best approximation / the minimum errors occurred if the third rank polynomial function is applied, so the best matching offers the dependencies presented as equations (4) - (6).

Table 1. Experimental and determined results of the processing time for OP thickness of 45 mm

Induced power P [W]	Measured processing time $t_{măs}$ [sec]	Calculated processing time t_{calc} [sec]
1170	420	420.331
2640	150	151.758
3120	150	141.452
3300	150	142.091
3600	126	145.713
4800	140	128.582
5200	80	86.074

Table 2. Experimental and determined results of the processing time for OP thickness of 50 mm

Induced power P [W]	Measured processing time $t_{măs}$ [sec]	Calculated processing time t_{calc} [sec]
1170	480	480.000
3360	160	160.000
3600	180	160.000
4680	120	120.000

Table 3. Experimental and determined results of the processing time for OP thickness of 65 mm

Induced power P [W]	Measured processing time $t_{măs}$ [sec]	Calculated processing time t_{calc} [sec]
1040	1140	1134.944
1920	420	439.475
2880	270	236.677
3600	250	272.811
4680	300	296.094

$$t = -2{,}10164 * 10^{-8} * P^3 + 2{,}28327 * 10^{-4} * P^2 - 0{,}81247 * P + 1092{,}02195 \quad (4)$$

$$t = -5{,}68785 * 10^{-8} * P^3 + 5{,}56847 * 10^{-4} * P^2 - 1{,}72504 * P + 1827{,}12421 \quad (5)$$

$$t = -6{,}21447 * 10^{-8} * P^3 + 6{,}7763 * 10^{-4} * P^2 - 2{,}3757 * P + 2942{,}6473 \quad (6)$$

The graphical representation of the t functions, experimentally and, respectively, theoretically determined, using the Mathcad application (MathSoft, Inc.) is displayed in the figures 1-3 (where the continuous line represents the interpolation function based on the experimental values and the dashed line represents the mathematical 3rd rank functions).

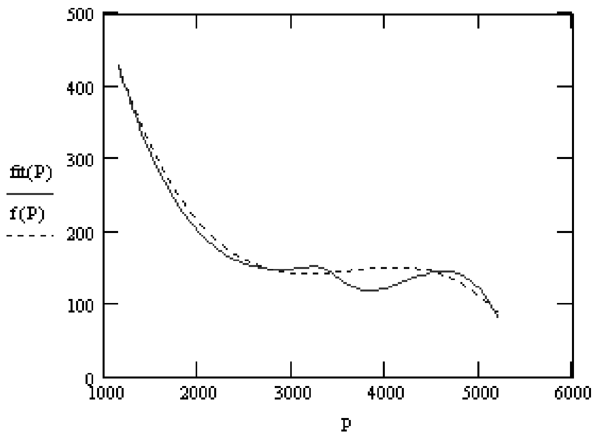

Figure 1. Graphical representation for PO diameter of 45 mm

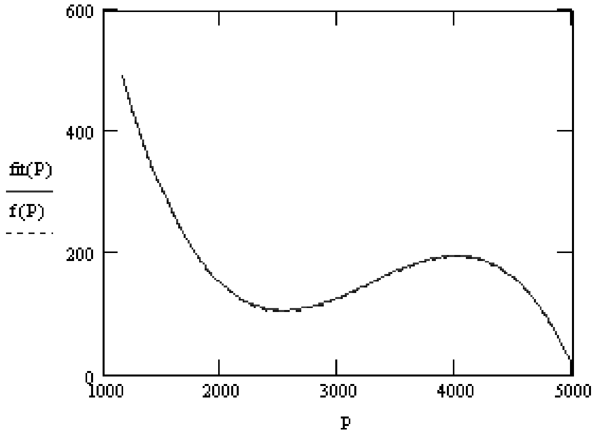

Figure 2. Graphical representation for PO diameter of 50 mm

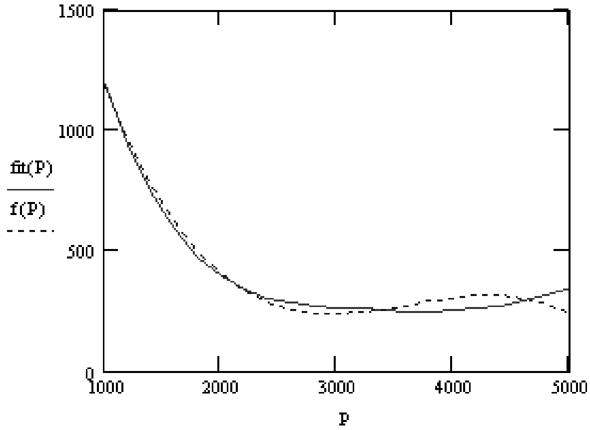

Figure 3. Graphical representation for PO diameter of 65 mm

The majority of errors don't surpass 10%, so we presumed that the elaborated pattern is correct and it can be used as a basis to determine the processing time dependency on the induced power.

3. DEBITING TIME OPTIMIZATION USING GEOGEBRA

In some circumstances, the use of empirically determined coefficients is not the best answer to the problem. Therefore a mathematical software solution may be implemented in order to obtain quickly a better precision with low cost computing effort.

In order to solve this task, we used GeoGebra ([***12]), a new and open-source instrument for mathematical and statistical calculus.

The main goal of the mathematical function is to determine the optimal debiting conditions of the materials which accept the processing through complex electric-electrochemical erosion. Then, the computer application allows the selection of the work conditions, presenting a selection from the database containing data on similar experiments (Figure 7).

It must be mentioned that, if the database contains no information on the similar experiments, the program emits a warning message and the optimization is finished without success.

Our computer application obtains information on the selected processing technology, according to some classification criteria such as: the processing machine, the material, the shape and the dimensions of the processed and transfer object, the material and the way of using the work liquid etc. ([Kar04])

Figure 4. Graphical representation for PO diameter of 45 mm

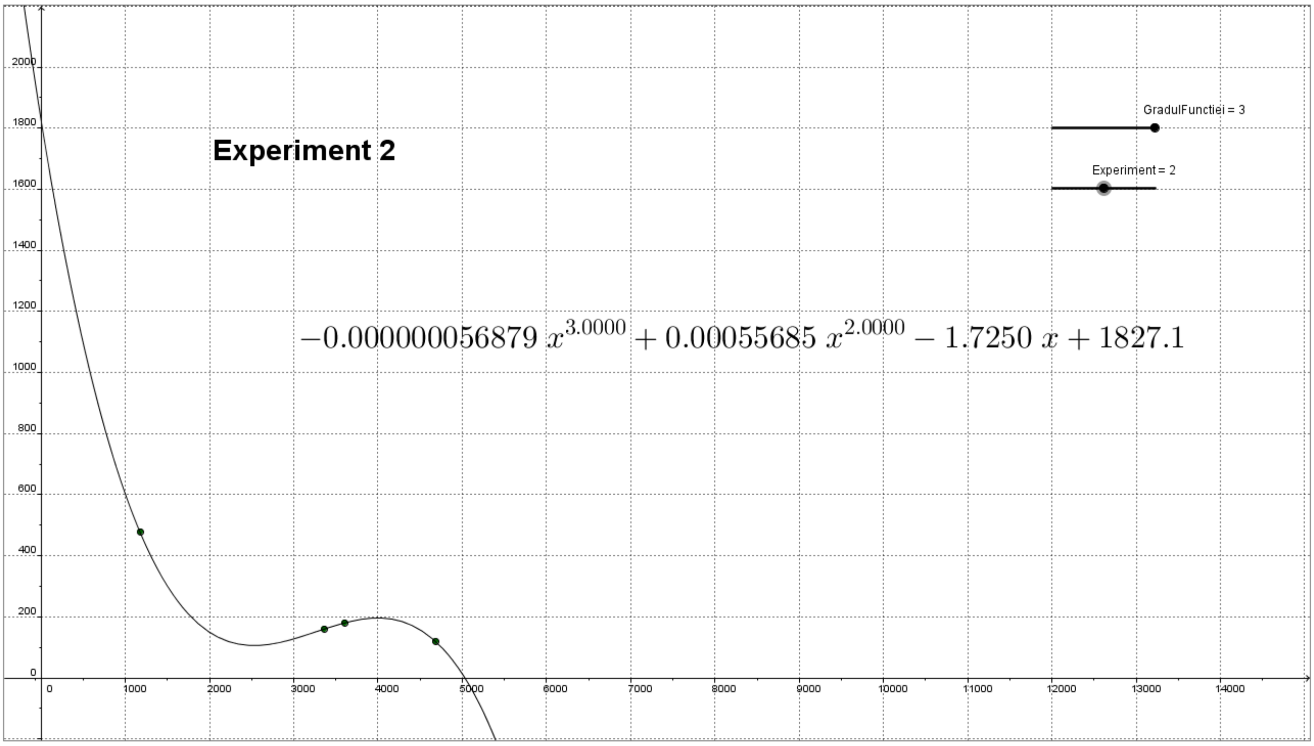

Figure 5. Graphical representation for PO diameter of 50 mm

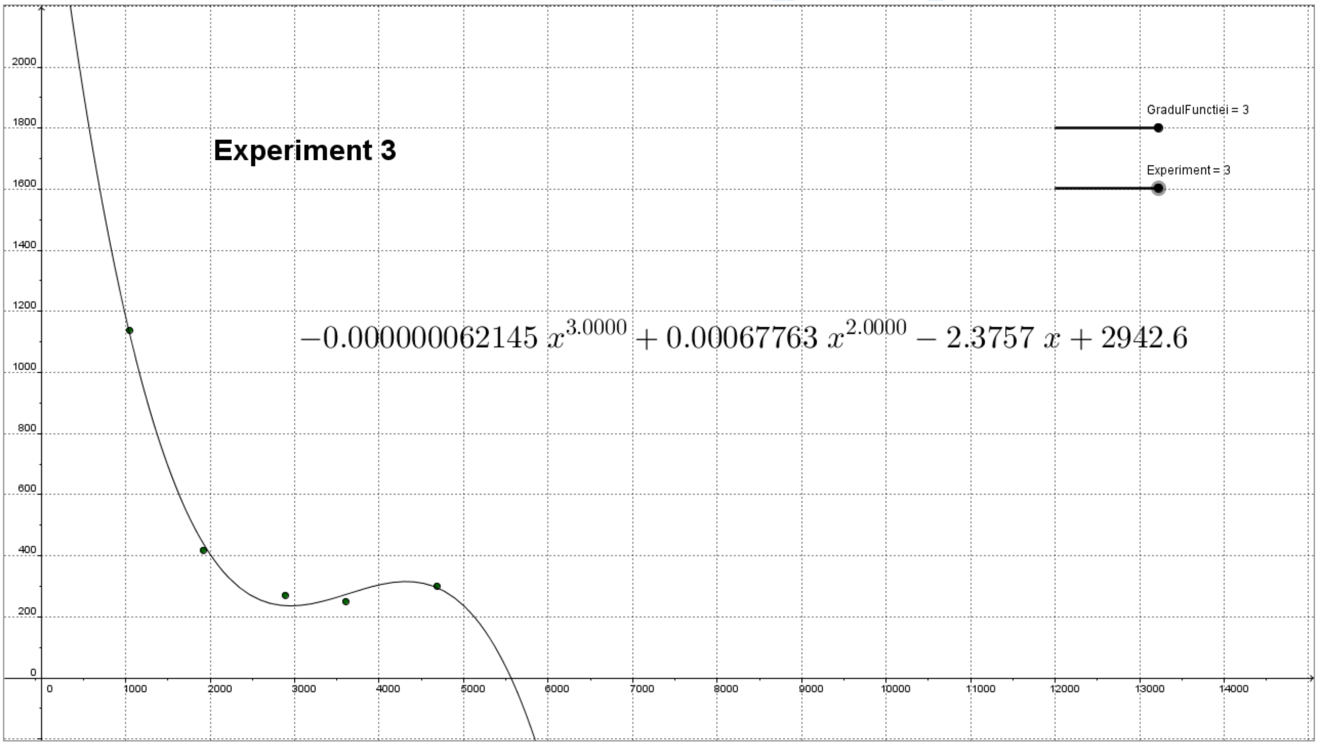

Figure 6. Graphical representation for PO diameter of 65 mm

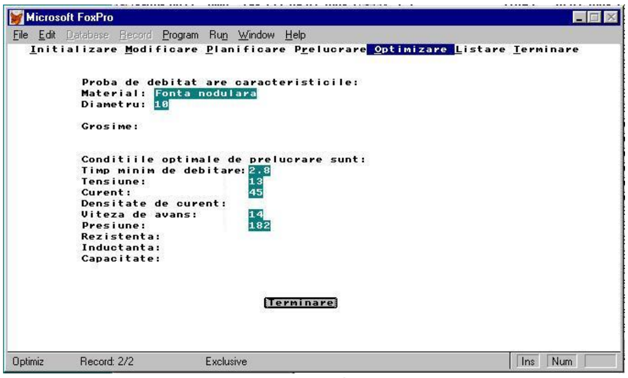

Figure 7. The result of the optimization

Using GeoGebra, this system automatically establish the algorithm of the mathematic model and the optimization algorithms for each experience set present in the database. This is very helpful for a user who wants to implement this technological procedure, because it permits to choose the work conditions which supposes a minimum processing time, an optimal quality of the result and the lowest possible forces and middles expenditure.

4. CONCLUSIONS

The use of the mathematical modeling instruments in the technological processes makes the user able to know the working way and the specific consumptions, which will determine the selection of the best values of the process input parameters. This result saves manufacturing, saves materials and reduces energy consumption, increasing the advantages and the benefits of using the nonconventional processing methods.

Based on the computer software, a computer can be used to assist the human operator at the cutting process. The computer program apply traditional methods for data fitting, as the method of least square, or modern methods as the GeoGebra software.

Using a database which stores the previous similar results, the human operator can choose those working conditions which offer a minimum cutting time, an optimal surface quality and the lowest possible forces and resources consumption.

The use of the calculus systems to improve the performances of the processing machines usually represents a much cheaper solution than the acquiring of machines with automatic integrated systems. Also, the presented principles offer the possibility of determining other parameters, in the circumstances of the existence of information in the database or other similar technologic processes.

5. REFERENCES

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

[H+99] **R. Herman, Z. Lăncrăngean, A. Mărcuşanu** - *Contribuţii privind determinarea teoretico-experimentală a productivităţii şi uzurii relative la prelucrarea oţelurilor inoxidabile prin eroziune electrică complexă*, Revista de Tehnologii Neconvenţionale No. 1/1999, pp. 46-48, 1999

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

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

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

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

[NL86] **A. Nanu, Z. Lăncrăngean** - *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 May 2012