ELECTROCHEMICAL DEBURRING OF MINING HYDRAULIC ELEMENTS

IOAN-LUCIAN BOLUNDUȚ*

Abstract: The paper presents the principle of rocks processing through electrochemical erosion, on the basis of the anodic dissolution. Following these, are presented the machine-tool block diagram for this processing, as well as the electrolytes and the electrodetools. Between the practical applications of the process, the paper insists on the electrochemical burring of some hydraulic elements for powered support command and regulation. The electrochemical burring is recommended for pieces with internal burrs, hard accessible, resulted after some holes, that intersect, processing.

Keywords: electrochemical deburring; electrochemical erosion; electrode-tool.

1. INTRODUCTION

Electrochemical deburring is based on the *phenomenon of anodic dissolution,* in other words, the material of which the anode is made is transferred into the solution, through simple chemical reactions. The positive ions from the anode are transferred into the solution, a react with the negative ions from the electrolyte, forming chemical compounds (metal hydroxides) that are deposited in the form of residues in the electrolyte. Advantages: high processing productivity; high dimensional precision and surface processing quality; processing does not result in structural modifications or tensions in the processed part; possibility to have pieces in their final form, without subsequent processing. In the meantime, the procedure requires costly installations, and the work parameter control is difficult.

Figure 1 is schematically represented by a process of anodic dissolution of steel, the electrolyte being an aqueous NaCl solution. iron hydroxides will be deposited in the electrolyze tub, and the hydrogen released at the cathode is dispersed in the atmosphere along with other noxious matter, therefore the baths will be closed and provided with forced ventilation.

---

* *Professor at the University of Petroşani, D.Sc., ibol@upet.ro*

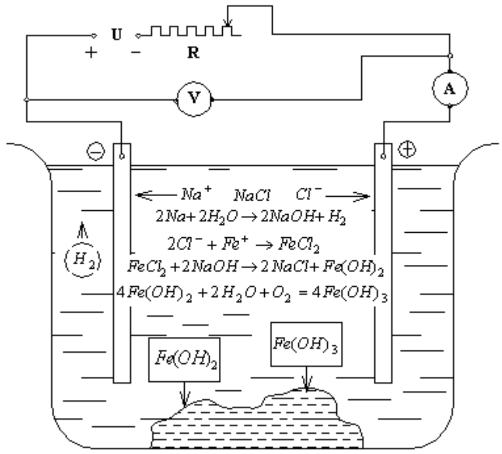

Fig.1. Processing diagram by electrochemical erosion.

Electrochemical processing productivity is the quantity of chemically dissolved matter under the action of electricity, in time unit. The effective amount of eroded metal from the anode is determined by Faraday's Laws.

First Law: the weight of a substance deposited by an electrode during electrolysis, is proportional to the electricity that passes through the electrolyte:

$$m = K \cdot I \cdot t \cdot \eta \text{ [g]} \tag{1}$$

where: K – electrochemical equivalent of the substance [mg/C]; I – electricity intensity [A]; t – time for electricity to pass[s]; η- electricity efficiency (ratio of matter effectively dissolved and matter theoretically dissolved) [%].

Second Law: when the same amount of electricity passes through solutions with various electrolytes, the amount of each of the substances set out for transformation are proportional to their chemical equivalents:

$$\frac{K}{M} = 0{,}01036 \quad \text{or} \quad K = 0{,}01036\frac{Ag}{\upsilon} \tag{2}$$

where: Ag – atomic weight of silver[g]; υ - atom valence in molecular combination; $Ag/\upsilon = M$ – equivalent [g/A·h].

Volume of eroded matter:

$$V = \frac{I \cdot t}{96.500} \cdot \eta \cdot \frac{A}{\rho} \text{ [cm}^3\text{]} \tag{3}$$

where: F = 96.500 – Faraday's number [A·s]; ρ- metal density[g/cm^3]; A – atomic weight of metal set out for erosion.

Processing productivity is directly proportional to electricity intensity and time for electricity to pass through, and inversely proportional to the matter density and its valence.

2. PROCESSING MACHINES BY ELECTROCHEMICAL EROSION

Processing machines by electrochemical erosion fall into several categories. They can be: universal or specialized, with normal of high electrolyte pressure, low, medium or high power, with one or several jobs, and with vertical, horizontal or inclined working heads.

Irrespective of the design type, all processing machines using electrochemical erosion are made up of three subassemblies: processing machine-tool, electrolyte circulation unit, and direct current generator with actuation system.

Figure 2 shows the diagram of such an installation. Thus, the *AC* direct current unit is made up of a *TR* power transformer, a *RD* rectifier, and regulation and control apparatus. The working currents reach up to 50.000 [A], and tension is 5…24 [V].

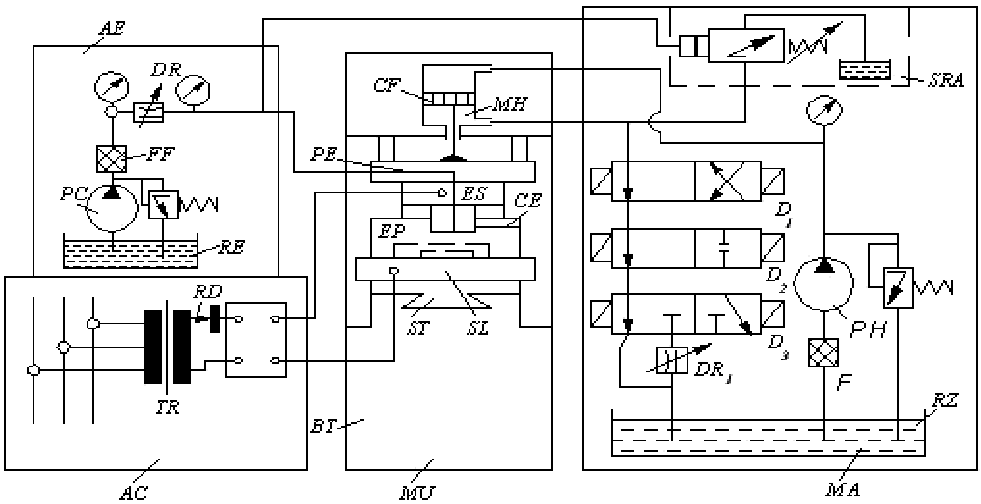

Fig.2. Diagram for processing machines using electrochemical erosion [15].

The *AE* electrolyte circulation unit is made up of *RE* electrolyte reservoir, *PC* constant flow pump with *FF* fine filter, *DR* throttle and unit control and safety equipment.

The group of mechanisms for *MA* self-adjustable advance system is made up of *PH* hydraulic pump, with *F* filter, *RZ* oil reservoir, D_1, D_2 and D_3 control distributors and DR_1 throttle, and *SRA* automatic regulating system. The automatic regulating system is controlled by the electrolyte's pressure entering the working area and as the existing working gap lessens, it hinders electrolytes short-circuiting. Similarly, when working gap increases, a continuous regulation of the electrolyte-tool advance, as well as an automatic working cycle is provided.

MU machine-tool is made up of *ET* frame, *ST* transversal slide and *SL* longitudinal slide executing straight movements along two rectangular coordinates, the *CE* electrolyte-tool tub, the *PE* plate of *ES* electrolyte-tool and the *CF* force head, actuated by *MN* linear hydraulic motor.

3. ELECTROLYTES AND ELECTROLYTE-TOOLS USED

In the process of electrochemical processing, the electrolyte has the following functions: provides closure of the electric circuit between the electrolyte-tool and the part; removes the heat made during the working process. For this, the electrolyte will have the following qualities: high electric conductibility; low toxicity; minimum corrosive effect; chemical and electrochemical stability.

During electrochemical processing, *a passive film* is formed on the surface of the parts, impeding erosion to go on. This film is removed by the electrolyte in two ways:

- *natural de-passivization,* when erosion products are removed with the forces resulted from reaction gas release or are dissolved in the electrolyte;
- *hydrodynamic de-passivization,* when erosion products are removed due to electrolyte flow under pressure in the working interstice.

Table 1 shows the electrolyte that can be used for electrochemical erosion, highlighting the fields of application, as well as their advantages and disadvantages.

Table 1. **Electrolytes used in the processing by electrochemical erosion [9]**

Electrolyte type	**Field of application**	**Concen-tration**	**Advantages**	**Disadvantages**
NaCl	- Steel - Cast iron - Aluminum alloys - Copper alloys - Nickel alloys - Cobalt alloys - Molybdenum alloys - Titanium alloys	30%	- Cheep - Nonflammable - Non toxic	- Large working interstice - Inter-crystalline attack action - Conductibility depends on temperature
H_2SO_4	- Steel	10%	- Use for very small diameter holes	- Expensive - Corrosive - Consumed during work
NaCl + NaOH	Metal carbides	15% NaCl + 3% NaON	- Very hard materials used	- NaOH is consumed during work
NaCl + NaOH + $NaNO_3$	- Wolfram - Wolfram carbides	5%	- Hard materials are used	- It is consumed during work

Regarding electrolytes-tools, the calculus and their structure involve theoretical determination of their geometrical shape, depending both on the profile that has to be accomplished and on the processing conditions. In general, they are made of highly conductive materials that should meet hardness criteria and other special mechanical features: electrolytic copper, graphite, brass, aluminum and steel. A special influence on the processing precision, as well as on productivity is played by the constructive shape of the attack area of the electrode-tool. In our case–electrochemical deburring of mining hydraulic elements bore holes – electrolytes-tool should be insulated from an electrical point of view, in the areas that should not be processed (Fig. 3). Similarly, the electrode-tools heads can have several design shapes; they might be analytically or analytically established.

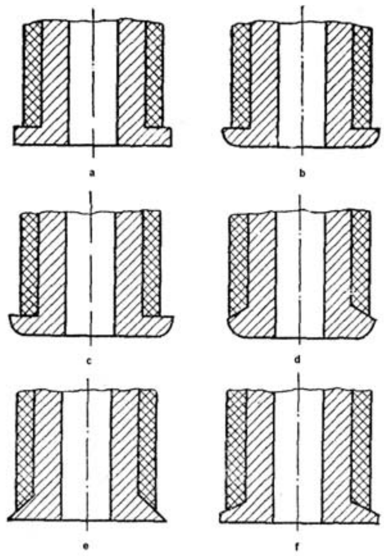

Fig. 3. Electrode-tools used to electrochemically deburr bore holes [12].

Electrolyte is introduced under pressure in the inside cylindrical canals of the electrode-tools and removes the resulted erosion product. Electrode-tools are connected to the negative pole of the direct current source, and the part to the positive pole.

4. ELECTROCHEMICAL DEBURRING

Practical applications of electrochemical erosion processing are numerous, being especially applied in carrying out various profiles in hard and extra-hard materials (inoxidable and refractory steel, metal carbides), as well as in obtaining complex configurations, difficult to obtain by classical procedures. There fore, several operations can be made by electrochemical erosion: puncturing, lathing, cutting, rectification, sawing, honing, polishing, deburring.

Electrochemical deburring can be carried out inside or outside cast, stamped or chipped parts, in stationary position or with electrode-tool advance. The increased efficiency of the procedure is due to the high density of the current developed on the prominent areas of the parts.

The paper suggests application of procedure to control and regulation hydraulic elements of powered mining supports that require a high processing precision. These parts have several inside intersecting bore holes and in the intersection areas inside burrs occur that might adversely influence the correct operation of the hydraulic installation, thus operational blocking might arise, by burrs being detached and entering in the hydraulic circuit of the installation. The burrs are in points that are not easily accessible and it is very difficult to remove them by classical methods, risking deteriorating the parts.

A few regulating hydraulic elements are presented below that could easily be electrochemically deburred. Thus, the *safety valve with nitrogen* (Fig. 4) is used for protection against overload for hydraulic cylinders. When the force in the hydraulic circuit is larger than the force generated by the nitrogen under pressure enclosed by the valve, this allows part of the working liquid to be removed by outlets, until balance is reestablished.

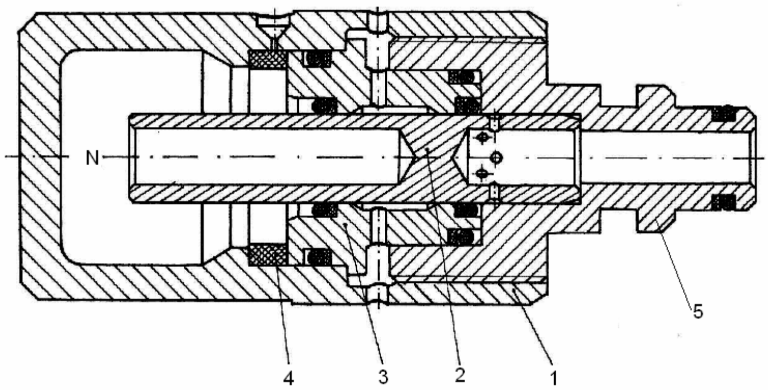

Fig. 4. Safety valve with nitrogen:
1- valve body; 2- piston; 3- valve sleeve; 4- sealing ring; 5- fixing cover

The valve of direction normally controlled in an open position (Fig. 5) is supplied by *P* joint, and the working liquid moves the piston and control rod, allowing it to move to *A* joint in the supply of the valve through *Y* joint, the piston moves in the opposite direction, and the control rod closes *P-A* route and opens *A-R* route.

The unblockable valve of direction (Fig. 6) is used to control the supply of a hydraulic cylinder in both senses, blocking and freeing the obstacle, respectively in only one direction. The valve is connected to a hydraulic distributor by *PA* and *PB* joints to the hydraulic cylinder. Thus, the working fluid goes through the valve and supplies the hydraulic cylinder through *A* joint. When it is no longer supplied, the valve is blocked under the action of a spring and obstructs the *A-PA* route, maintaining the pressure in the hydraulic cylinder. In the supply of the other sense of the hydraulic cylinder, the working fluid goes through *PB* and *B* joints, working on the deblocking piston allowing the fluid to be removed along *A-PA* route.

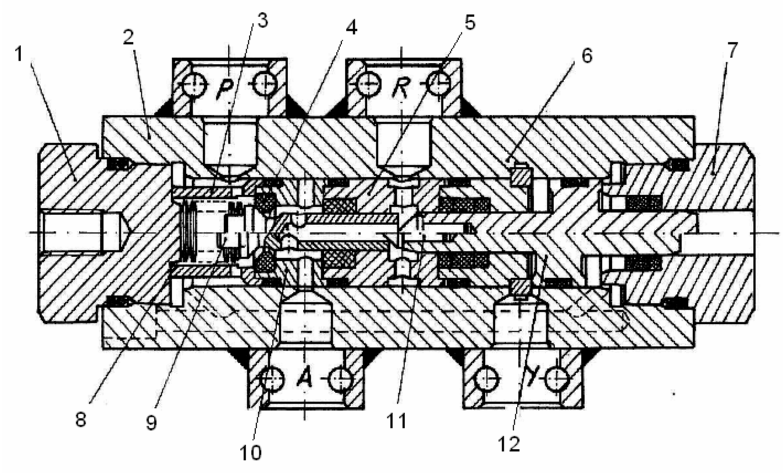

Fig. 5. Controlled direction valve normally open:
1- bored plug; 2- valve body; 3-spring guiding; 4- valve seat; 5-intermediary sleeve; 6- sleeve; 7- gland; 8- spring-disc; 9- control rod; 10- pass through sleeve; 11- sealing taper; 12- piston.

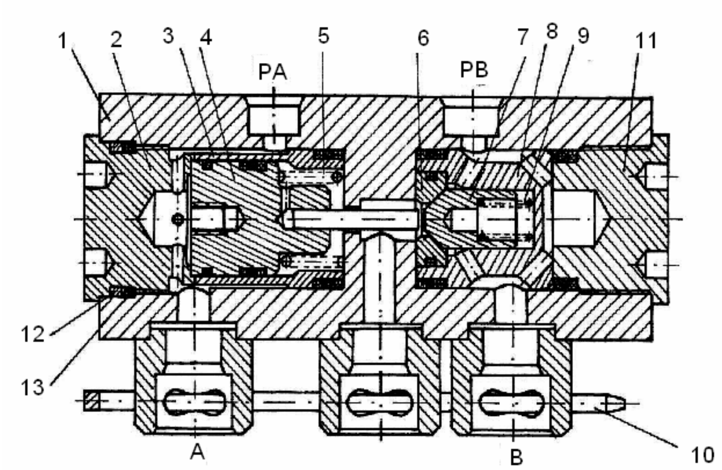

Fig. 6. Unblockable direction valve:
1- valve body; 2- cover; 3- piston sleeve; 4- piston; 5- come-back spring;
6- valve seat; 7- valve with taper; 8- valve sleeve; 9- spring; 10- coupling pin;
11- closing cover; 12- support ring; 13- „O” sealing ring.

Deblockable double direction valve (Fig. 7) is used to control the supply of a hydraulic cylinder, in both directions, blocking/deblocking directions, with direct connection to the piston rod, by which the hydraulic cylinder is supplied. For the one sense supply of the cylinder, the liquid enters in the valve by *PA* route and from here into the cylinder. Meanwhile, *7* piston rod deblocks *3* valve with taper, from *B* route, allowing working liquid to be removed. When supply ceases, the valve with taper from *A* route is blocked under the action of *4* pressure spring, and working liquid pressure, the liquid being maintained in the cylinder.

Functioning is analogous when the liquid enters in the valve by *PB* valve as well.

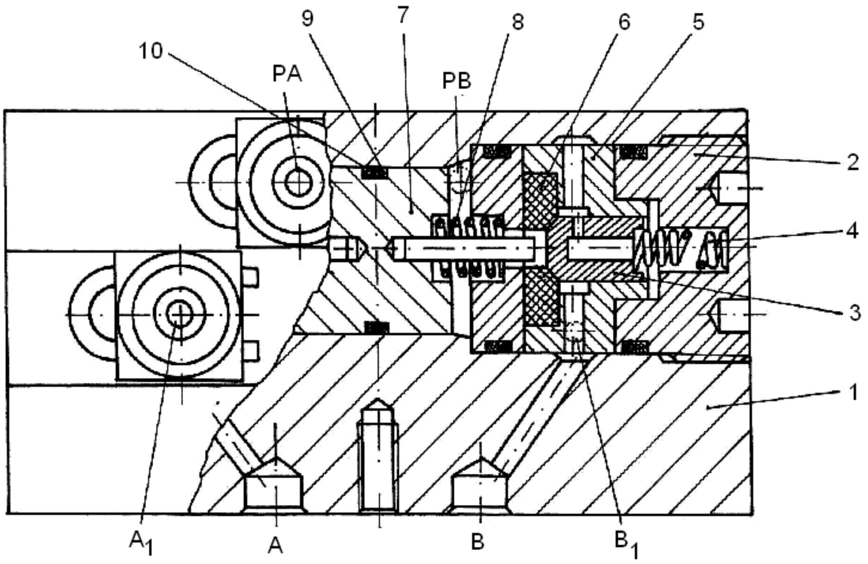

Fig. 7. Double deblockable valve of direction:
1- valve body; 2 cover; 3-tapered valve; 4-pressure spring; 5- guiding sleeve; 6-valve seat; 7-piston with rod, 8- come-back spring; 9-support ring, 10 – „O" sealing ring

Double deblockable valve of direction (Fig. 8) makes fluid go in a sense, from the distributor to the hydraulic cylinder. When supply ceases, the valve blocks, maintaining the working agent in the cylinder. The valve being double, it allows simultaneous supply of the two hydraulic cylinders, at the same working pressure. All valve elements are mounted in two longitudinal bore holes made in the body of the latter, and execution elements are connected to the safety valve and pressure manometer by rapid coupling outside sleeves.

5. CONCLUSIONS

The paper presents the principle of processing the parts of the machine construction by electrochemical erosion, based on the phenomenon of anodic dissolution. Due to the rounding phenomenon of the sharp edges, electrochemical erosion can successfully replace classical processing in case of removing burrs in cast parts, from toothed wheels and from processing profiled clogged holes, or complex, inside surfaces provided with connection radiuses. There are however limitations in electrochemical processing, mainly due to the fact that machine-tools used are very expensive, and the large number of existing electrical-technological parameters and their tight connection make algorithm application to the process quite difficult, experimental corrections being required, both regarding the shape of the electrode-tool, and the choice of the processing regimes.

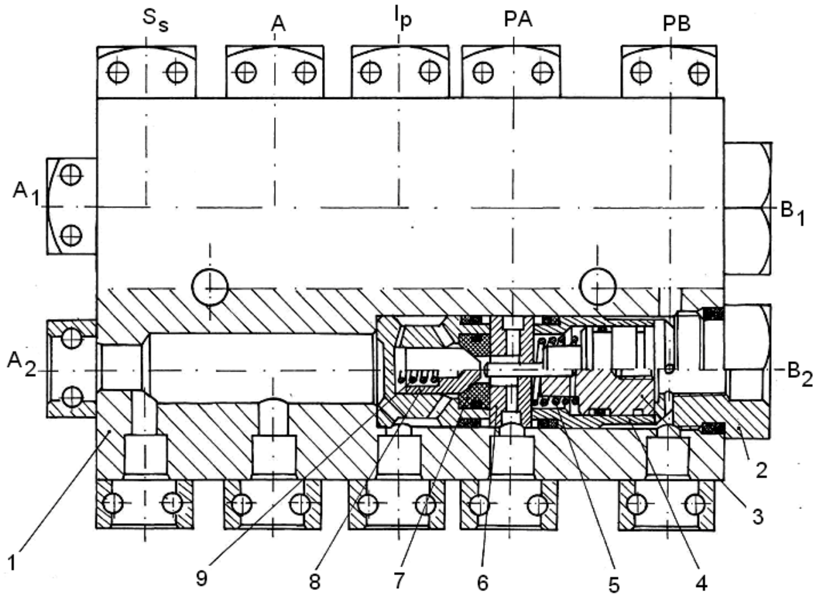

Fig.8. Double deblockable valve of direction:
1-valve body; 2 –piston cover, 3-piston with rod, 4-piston sleeve 5-come-back spring, 6-intermediary sleeve; 7-valve seat, 8-tapered valve; 9-pressure spring

Starting from these considerations, we propose the procedure to be used in case of control and regulation hydraulic elements of powered mining supports (couplings, sleeves, collars, valves and distributors). Some of these parts have inside intersecting bore holes and in the intersection areas burrs are formed and in case of their detachment, the hydraulic circuit of the installation would be blocked. Traditional deburring is difficult, therefore electrochemical deburring is recommended.

REFERENCES

[1]. **Amza, G., Rîndescu, V.O., Dumitru, G.M., Amza, C.G.,** *Essay on the technology of materials* (vol. 2), The Publishing House of the Romanian Academy, Bucharest, 2002 (Romanian language)

[2]. **Antropov, L.**, *Theoretical Electrochemistry,* Mir Publishers, Moscow, 1972

[3]. **Bolunduț, I.L.,** *Electrochemical Burring of Mining Hydraulic Elements,* Scientific papers of the International Multidiscipliaanry Symposium "Universitaria Simpro 2008" (Technological Machines and Equipments), pg. 91-95, Universitas Publishing House, Petrosani, 2008

[4]. **Bolunduț, I.L.,** *Electrochemical Polishing of Metallographic Specimens*, Scientific papers of the International Multidiscipliaanry Symposium "Universitaria Simpro 2010" (Technological Machines and Equipments), pg. 111-114, Universitas Publishing House,

Petrosani, 2010
[5]. **Ceaușescu, N., Popescu, I.,** *Non – conventional technologies*, Scrisul Romanesc Publishing House, Craiova, 1982, (Romanian language)
[6]. **Davydov, A.D., Volgin, V.M.,** *Encyclopedia of Electrochemistry,* Wiley-VCH Verlag GmbH & Co., 2007.
[7]. **Gale, W.F., Totemeier, T.C.**, edited by *Smithells Metals Reference Book (8th edition),* Butterworth - Heinemann, 2004.
[8]. **Gao, H., Jin, Z., Rui, Y.,** *Precision Surface Finishing and Deburring Technology,* http:/www.scientific.net/0-87849-461-8.
[9]. **Gavrilaş, I., Marinescu, N.I.,** *Non – conventional processing operations during the manufacturing of machines (vol.I)*, Technical Publishing House, Bucharest, 1991, (Romanian language)
[10]. **Hazard, C., Lelong, F., Quinzain, B**., *Mémotech structures métalliques,* Casteilla, 1997.
[11]. **Jacquet, P.A.,** *Le polissage électrolytique des surfaces métalliques et ses applications,* Edition Métaux, 1948.
[12]. **Marinescu, N.I.,** *Use of electrochemical processing during the manufacturing of machines*, Technical Publishing House, Bucharest, 1982, (Romanian language)
[13]. **McGeough, J.,** *Electrochemical Machining,* http://electrochem.cwru.edu/encycl/.
[14]. **Mehedințeanu, M., Hollanda, D., Sporea, I.,** *Mechanical technology and tool – machines,* Didactical and Pedagogical Publishing House, Bucharest, 1982, (Romanian language)
[15]. **Moraru, V., Plăhteanu, B., Velicu, S., Aurite, T.,** *Special tool - machines,* Didactical and Pedagogical Publishing House, Bucharest, 1982, (Romanian language)
[16]. **Nanu, A.,** *Technology of materials,* Didactical and Pedagogical Publishing House, Bucharest, 1977, (Romanian language)
[17]. **Nichici, A.,** *Processing by erosion during thee manufacturing of machines,* Facla Publishing House, Timisoara, 1983, (Romanian language)
[18]. **Pálfalvi, A., Mehedințeanu, M., Andrei, E., Nicolae, V., Breştin, A., Şontea, S., Floriganță, G.,** *Technology of materials,* Didactical and Pedagogical Publishing House, Bucharest, 1985, (Romanian language)
[19]. **Zhai, X.B., Wang, H., Xu, W.I., Li, H.Y., Zhon, I.I.,** *Research on Techonoligy and Aplication of Pulse Electrochemical Finishing,* http:/www.scientific.net/requestpaper/57205.