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TECHNOLOGICAL CHARACTERISTICS OF THE PROCESSING THROUGH ELECTRICAL OR ELECTROCHEMICAL COMPLEX EROSION

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ABSTRACT: The theoretical and experimental study of the processing through complex electrical erosion achieved until now, reveals the existence of a complex process guided and thoroughly influenced by a series of parameters and factors that acts simultaneously, whereas others acts independently. Their characteristics determine the proportion of participation at drawing the material of one of the specific elementary processes, in this way determining the global erosive effect and finally the characteristics of the processing.

The characteristics are expressed through many parameters and are influenced by a series of factors so that the sense of the two notions are obviously different: the parameter is a size belonging to an object serving at characterizing some of his properties whereas the factor represents a condition determining the emergence of a process of a phenomenon, as well as its developing.

The technological characteristics are those variables which express quantitatively and qualitatively the changes which the processed object OP and the transferred object OT suffers during the processing namely:

- the precision OP;
- the condition of the OP surface ;
- the productivity of processing Q_{OP};
- attrition/ abrasion.

The final technological characteristics depend on the size and the variation mode of the above elements, the influences among them establishing the processing of elementary phenomena and the stability of the erosive process. Yet, during the process there are also deviations of the parameters following the influence of some factors, which will determine errors in the final outcome of processing.

1. Characteristics of Geometrical Precision

Geometrical precision means the degree of coverage of the dimensions, geometrical shape and also the mutual position of the processed surfaces compared to the nominal values shown in the drawing. The characteristics of geometrical precision are:

- dimensional precision of the processed object;
- the precision of geometrical shape of the processed object;
- the precision of the mutual position of geometrical elements in connection with some reference bases.

2. The Characteristics of the Surface Conditions

The conditions of the surfaces of the obtained components may be obtained through the characteristics expressing the geometrical condition and the physical and chemical conditions of the surface:

- the geometrical condition of the surface expresses the geometrical deviation of the real component compared to the geometrical component of the execution documentation. They may be:

- undulation
- ruggedness

- the physical and chemical condition of the surface expresses the physical, chemical and mechanical properties of a film of the superficial layer compared to the rest of the material. They may be:
  - the superficial layer thermo altered having a certain depth characterized by:
    - altering in chemical composition;
    - altering in metallographic structure;
  - plastic deformation after the altering of the size and distribution of internal tension;
  - resistance in abrasion and corrosion.

The deviations of geometrical shape are called deviations of the first degree and were presented previously.

The undulations are called deviations of the second degree and they represent the assembly of non-uniformities whose pitch is few times bigger than their depth. They have the aspect of waves periodically succeeding because of the non-uniformity of the processing, of some vibrations in the technologic system etc. When the waves are not periodic they are not undulations but deviations from the geometrical shape of the surface.

Ruggedness represents the remains on the surface OP after the technologic process consists of deviations of the third degree and deviations of the fourth degree. They are micro-non-uniformities depending on the kinematics of the processing and have a periodic character, they being composed of striate or scratches and of snatchings remains on OT.

Ruggedness is expressed quantitatively through the following indices:

- the deviation of the profile defined as average value of the ordered axes of the profile effectively compared to the average line of the real profile;
- the height of the non-uniformities as an average distance among the five highest points and the lowest five points of the bottom real profile;
- the maximum depth of the non-uniformities R_{max} defined as being the highest distance between the real profile and the average line. Whether in case of singular pieces the ruggedness is not very important, for the assembled pieces/ components it is of paramount importance because of the resistance in abrasion of the surfaces, resistance in tiredness, corrosion, durability, aspect, maintaining the report of contact dimensions within the limits admitted for assembly, the dimensional precision etc.

Some values of the ruggedness of a component obtained through different processing proceedings are presented in the table 1.

The thickness of the layer superficially, thermo altered is an alteration of the physical and chemical properties of the superficial layer, after the technological process.

The chemical composition and the metallographic structure of the layer superficially thermo altered may be altered during the processing, comparatively to the same characteristics of the basic material because of the thermo field resulted.

The plastic deformation of the superficial layer is an alteration of the surface OP, after the mechanical stress and the thermo cycle and it is usually accompanied with the augmentation of the micro-hardness of the superficial layer, as a consequence of hammerhardening. The deformation is due to the emergence of some internal tensions, differing from the size and distribution initially existent in OP.

Table 1. Informative values of the ruggednees of the surface depending od the technologic processing

Technologic process	Average values of the ruggedness R_a [µm]														
	0,006	0,012	0,025	0,05	0,1	0,2	0,4	0,8	1,6	3,2	6,3	12,5	25	50	100
Reaming								■	■	■	■				
Boring						■	■	■	■	■					
Swaging						■	■	■	■	■	■				
Sewing							■	■	■	■	■	■			
Jet cleaning								■	■	■	■	■	■	■	■
Barrel cleaning			■	■											
Electro-chemic			■	■	■	■	■	■	■	■					
Electro-errosion					■	■	■	■	■	■	■	■			
Extrusion								■	■	■	■	■			
Circular milling							■	■	■	■	■	■			
Front milling							■	■	■	■	■	■			
Piercing				■	■	■	■	■	■	■	■				
Long run honing	■	■	■	■	■	■	■	■							
Short run honing	■	■	■	■	■										
Reaming				■	■	■	■	■	■	■	■				
Straight-line lapping of rubbing	■	■	■												
Plane straight-line lapping	■	■	■	■	■	■	■	■							
Round straight-line lapping	■	■	■	■	■	■	■	■							
Dying								■	■	■	■	■			
Mortising							■	■	■	■	■	■			
Filing							■	■	■	■	■	■			
Rubbing		■	■	■	■	■									
Planning						■	■	■	■	■	■	■	■	■	■
Scaping						■	■	■	■	■	■				
Plane front rectification						■	■	■	■	■					
Round longitudinal rectification		■	■	■	■	■	■	■	■	■					
Plane rectification with the peripery of the stone						■	■	■	■	■					
Plane round rectification						■	■	■							
Round rectification advanced in depth					■	■	■	■							
Cutting off										■	■	■			
Plane rolling		■	■	■	■	■	■								
Hall-marking						■	■	■	■	■	■				
Longitudinal lathing						■	■	■	■	■	■	■	■	■	■
Plane lathing							■	■	■	■	■	■	■	■	■
Superfinish			■	■	■										
Cutting									■	■	■				
Cuting with flame										■	■	■			
Accurate moulding								■	■	■					
Moulding in iron chill								■	■	■					
Barked-shaped moulding								■	■	■					
Sand-shaped moulding								■	■	■					
Under pressure moulding								■	■	■					

Resistance in abrasion is altered after the technological processing in connection with the emergence and size of the fissures in the superficial layer.

Among the causes which influence the quality of the processed surface, not depending by the technological parameters can be enumerated:

- the geometry OT;
- the material quality OT;
- the ruggedness of the technological system machine-OT-Op.

3. Characteristics of processing productivity

Productivity, which is an essential technological characteristic of any processing, is expressed through a number of indices, in the case of the complex erosion:

- the volume of the total drawing: represents the total volume of drawn material of OP:

$$V_{OP} = (V_{EP} + V_{DA}) \cdot f_{EP} \cdot t_p = \frac{m_{OP1} - m_{OP2}}{\rho_{OP}} \text{ [mm}^3\text{]} \quad (1)$$

- the total mass drawn: represents the total mass of drawn material of OP:

$$m_{OP} = (m_{EP} + m_{DA}) \cdot f_{EP} \cdot t_p = (m_{OP1} - m_{OP2}) \text{ [g]} \quad (2)$$

- the volume productivity of the drawing (volume debit of drawing): represents the volume of drawn material in time unit:

$$Q_{OP} = \frac{V_{OP}}{t_p} = (V_{EP} + V_{DA}) \cdot f_{EP} \text{ [mm}^3\text{/min]} \quad (3)$$

- the mass productivity of the drawing: represents the mass of drawn material in the time unit:

$$Q_{OP}{}^m = \frac{m_{OP}}{t_p} = (m_{EP} + m_{DA}) \cdot f_{EP} \text{ [g/min]} \quad (4)$$

- the specific productivity of the drawing: represents the energetic efficiency of the drawing:

$$q_{OP} = \frac{Q_{OP}}{I_m} \text{ [mm}^3\text{/A·min]} \quad (5)$$

$$q_{OP}{}^m = \frac{Q_{OP}{}^m}{I_m} \text{ [g/A·min]} \quad (6)$$

- medium speed of advance s_m [m/s]: represents the medium speed with which the advance movement takes place;
- the time of processing t_p [min or s]: represents the time of unfolding of processing.

4. Characteristics of abrasion of the transfer object

The characteristics of abrasion of OT show the transformations upon OT during the technological process and are expressed through some indices, similarly defined with those applied upon OP:

- the volume of the total worning: represents the total volume of worn material drawn from OT

$$V_{OT} = V_{ET} \cdot f_{EP} \cdot t_p = \frac{m_{OT1} - m_{OT2}}{\rho_{OT}} \quad [mm^3] \quad (7)$$

- the total worn mass: represents the total mass of worn material drawn from OT:

$$m_{OT} = m_{ET} \cdot f_{EP} \cdot t_p = m_{OT1} - m_{OT2} \quad [g] \quad (8)$$

- the volume debit of the abrasion: represents the volume of worn material drawn from OT:

$$m_{OT} = m_{ET} \cdot f_{EP} \cdot t_p = m_{OT1} - m_{OT2} \quad [g] \quad (9)$$

- the mass debit of abrasion: represents the mass of worn material drawn from OT:

$$Q_{OT}{}^{m} = \frac{m_{OT}}{t_p} = m_{ET} \cdot f_{EP} \quad [g/min] \quad (10)$$

- the specific debit of abrasion: represents the volume/ mass of worn material removed from OT in the time unit under the action of a medium current 1 A:

$$q_{OT} = \frac{Q_{OT}}{I_m} \quad [mm^3/A \cdot min] \quad (11)$$

$$q_{OT}{}^{m} = \frac{Q_{OT}{}^{m}}{I_m} \quad [g/A \cdot min] \quad (12)$$

- the relative volume abrasion: represents the percentage volume worn from OT for drawing the volume unit out of OT:

$$\nu_u = \frac{V_{OT}}{V_{OP}} \cdot 100 = \frac{Q_{OT}}{Q_{OP}} \cdot 100 \quad [\%] \quad (13)$$

5. Costs

The characteristics of applied costs to EEC process show the expenditures made on the occasion of the processing of OP and is expressed through a number of indices:

- the cost OT: represents the expenditures with OT used during the processing:

$$C_{OT} = K_{OT} \cdot Q_{OT} \cdot C_{OTM} \quad [lei/min] \quad (14)$$

Where:
K_{OT} represents a coefficient of processing in OT cost of othe expenditures
C_{OTM} represents the specific cost of the material OT [lei/ mm^3}

- the LL cost: represents the expenditures with LL used during the processing:

$$C_{LL} = K_{LL} \cdot Q_{LL} \cdot C_{LLM} \quad [lei/min] \quad (15)$$

Where:
K_{LL} represents a coefficient depending on the time between two alterations of LL
Q_{LL} represents the volume of LL used during the processing {l/min]
C_{LLM} represents the specific cost of the material LL [lei/l]

- the cost of energy: represents the expenditures with electric energy used during the processing:

$$C_{EE} = K_{EE} \cdot (N_{OT}+N_{LL}+N_p) \cdot C_{EEM} \quad [lei/min] \quad (16)$$

Where:

K_{EE} represents a coefficient depending on the processing conditions
N_{OT} represents the used energy with OT movement [kW]
N_{LL} represents the used energy with circulation LL [kW]
N_P represents the used energy by the process [kW]
C_{EEM} represents the specific cost of energy {lei/ kW]

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