A sequence of calculation of the modes of dimensional combined processing by an electrode brush

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A sequence of calculation of the modes of dimensional combined processing by an electrode brush

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Abstract. In the article the way of calculation of the modes of dimensional processing by an electrode brush is considered. The choice of a liquid working environment is presented. A calculation of tension in electrodes and forces of the technological current realized during processing is given. A choice of a clip of wire bunches in a processing zone, feeding an electrode brush to a non-rigid work piece. The recommended technological indicators of the process of the finishing combined treatment by an electrode brush are presented.

1. Introduction
The complexity of output products continually grows and nomenclature of their production rises. At the same time development, designing and production requirements are getting more rigid. In these circumstances the method of dimensional treatment, by means of an unshaped brush electrode with a working section made from the cantilever fitted wire, which has great elasticity, universality and ability of fast switching to processing of products of a different construction, is advantageous.

As a result of such type of processing a blank part is affected by the combined influence of erosion, chemical and mechanical processes. Their interpenetration allows implementing efficient processing of products made from high-strength and hard materials with high quality and accuracy.

2. Working medium selection
For a combined process of final treatment by means of the brush electrode it is required to choose [1] liquid mediums with low conductivity. They include: manufacturing water, lubricating and cooling fluid, dilute solutions of neutral salts (Table 1).

Experience of the use of working mediums specified in Table 1 has shown that manufacturing water has no stable properties and admixtures (for example, anticorrosion) can change the conductivity. That restricts the application of such composition for final treatment.

Lubricating and cooling mediums can be dielectric (on the basis of oils) and current-conducting and the conductivity depends on the solution concentration. An advantage of lubricating and cooling mediums is the availability of anticorrosion admixtures, for that reason medium preparation comes to concentrated fluid dilution up to required consistency [4].

For experimental works the solutions with the fixed composition and electric conductivity are used more often which allows one to reproduce experimental conditions.
The temperature of the working medium can influence electric conductivity. As applied to final treatment by means of the brush electrode even during long-term treatment, the temperature changes insignificantly (in the range of 1 ÷ 3 K) and that allows considering it as constant.

### Electrode voltage

An electrode voltage is the main operating characteristic of the treatment process by means of the brush electrode. In [1, 2] it is shown that the voltage in the mentioned process can be from 2 ÷ 3 V up to 12 ÷ 15 V. Such range of the variation does not allow determining the voltage required for a specific type of treatment of a single blank part.

The voltage according to requirements to the anodic dissolution process, which is performed according to the scheme with a constant inter electrode gap. Although being in the active part of the treatment process, the gap can change from $k_S$ to 0 when the tool approaches the treatment zone up to the range of $0-k_S$ – at the outlet. With some allowances it is possible to accept gap ($\rho_S$) as a half of $k_S$ ($\rho_S = \frac{1}{2} k_S$). Then the voltage ($U$) is

$$U = \frac{j_{wp} S_k}{2 \chi} + \Delta U,$$

(1)

where $j_{wp}$ – is maximum current density which can be conducted through the wire with diameter $d_n$.

Taking into account cooling of the brass wire by the liquid medium, which is most often used for final treatment [1, 3], we obtain:

$$j_{wp} = 8 \div 10 \text{ A/mm}^2$$

If a design value of the voltage meets the recommended range then the obtained value should be rounded (more often up to the value fixed in the generator) to the nearest greater value and calculations of regimes are made in accordance with these values.

### Manufacturing current strength

Current strength ($I$), implemented in the process is:

$$I = j_{wp} \overline{F}_0,$$

(2)

where $\overline{F}_0$ – open area of each beams line, mm².

$$\overline{F}_0 = \frac{\pi d_n^2}{4} \cdot N_n.$$  

3. **Table 1.** Working mediums compositions.

| № | Medium composition | Specific conductivity, Ohm⁻¹ m⁻¹ | Admixture content, % | Toxicity | Fire risk | Availability |
|---|-------------------|----------------------------------|----------------------|----------|----------|-------------|
| 1 | Manufacturing water with admixtures NaNO₂ | 0.002…0.004 | 0.5…0.2 | No | Nonflammable | Available |
| 2 | Lubricant and cooling mediums (Ukrinol 1, Akvol-6) | 0.004…0.06 | No | Insignificant | Flammable | Expenses required |
| 3 | Salt solutions (15-20% Na₂CO₃+oil I-20) | 0.008…0.012 | 10…15 | Insignificant | Nonflammable | Available |

The temperature of the working medium can influence electric conductivity. As applied to final treatment by means of the brush electrode even during long-term treatment, the temperature changes insignificantly (in the range of 1 ÷ 3 K) and that allows considering it as constant.
Then

\[ I = j_{np} \cdot \Pi D_n \cdot \frac{2}{4} N_n. \]  

(4)

Current strength \( I_B \) is:

\[ I_B = \eta_B I, \]

(5)

where \( \eta_B \) – coefficient of efficiency of the current source (for electronic sources \( \eta_B = 0.9 \div 0.95 \)).

\[ I_B = \eta_B \cdot j_{np} \cdot \Pi D_n \cdot \frac{2}{4} N_n. \]

(6)

5. Selection of clamping beams (\( \Pi p \)) of the cable for a work piece

A secured contact of the beam end with this place is enough for realization of mechanical cleaning of the working area by the brush electrode. Clamping may be calculated by the formula taking into account tolerances on treatment details (especially non-rigid constructions):

\[ \Pi p = [\delta] + \Pi p_0. \]

(7)

Where \([\delta]\) – the greatest value of tolerance on treatment area; \( \Pi p_0 \) – guaranteed clamping.

From the experience of brush electrode application it is known that cable ends may remain unbent during treatment of non-rigid details, but the cable can amortize in the process of treatment, that is why, during calculation of clamping, it should be considered:

\[ \Pi p_0 = \gamma_B \cdot L_z, \]

(8)

where \( \gamma_B \) – amortization along the length of the cable relating to the depth of removed material (\( \gamma_B = 5 \div 15 \% \)); \( L_z \) – length of the treatment area of the detail.

If the hardness of the cable is lower than the hardness of the treatment area of the half-finished product, then due to amortization of the cable in beam the reduction of its diameter occurs

\[ \Pi p_0 = \frac{\gamma_B \cdot K_{0z} \cdot I^2_a \cdot \mu \cdot I^2_a}{S^2_0} E, \]

(9)

where \( I_a \) – maximum current, which passes through the beam.

Then

\[ \Pi p \geq [\delta] + \frac{K_{0z} \cdot I^2_a \cdot \mu \cdot I^2_a}{S^2_0 E}, \]

(10)

here \( I_a = j_{np} \cdot S_n \), where \( S_n \) – beam cross-section.

For circular cross-section \( S_n = \pi \cdot l_{cp} / 4 \),

\[ I_a = j_{np} \cdot \frac{\pi \cdot l_{cp}}{4}, \]

(11)

where \( D_n \) – diameter of the beam.

6. Brush electrode feed

A speed of feed \( (W_v) \) determines all technological parameters of treatment. Reliable calculations and destination of the feed provide the required technological indexes of treatment by the brush electrode (primarily accuracy of the form and sizes and the quality of surface coat). It is necessary to remove the given allowance as a result of each pass \( Z_1 \). The removal speed of the allowance is measured as
\[ V = V_a + V_{ee}, \]  
where \( V_a \) – speed of anodic dissolution; \( V_{ee} \) – speed of electro erosion removal of the allowance.

\[ V_a = \frac{\alpha \eta \chi}{\gamma} \frac{2(U - \Delta U)}{S_k}, \]  
(13)

From [2]

\[ V_{ee} = K_{ee} A_u \frac{1}{q \cdot \tau_u}, \]  
(14)

where \( K_{ee} \) – coefficient defining the effectiveness of input energy of pulse \( A_u \); \( q \) – relative pulse duration; \( \tau_u \) – duration of pulse. When using experimental dimension coefficients (\( K_0 \), m/Vsec) for different materials,

\[ V_{ee} = \bar{K}_0 \cdot U. \]  
(15)

Then removal time of the allowance is

\[ \tau_n = \frac{Z_1}{V}. \]  
(16)

To provide equal removal of the allowance from the whole surface (\( L_z \)) it is necessary to calculate time \( \tau_{obr} \).

\[ \tau_{obr} = \frac{Z_1}{\frac{\alpha \eta \chi}{\gamma} \frac{2(U - \Delta U)}{S_k} + \bar{K}_0 \cdot U}. \]  
(17)

Then the speed feed is

\[ W_n = \frac{L_z \left( \frac{\alpha \eta \chi}{\gamma} \frac{2(U - \Delta U)}{S_k} + \bar{K}_0 \cdot U \right)}{Z_1}. \]  
(18)

7. Technological indexes of final treatment

The recommended modes of high speed dimensional treatment by the brush electrode are presented in Table 2.

| Parameter name | Value |
|----------------|-------|
| Voltage, V     | 4…6   |
| The size of a tool electrode contact and a half-finished product, mm | 0…0.2 |
| Radial speed of a tool electrode, m/s | from 35 |
| The diameter of a tool electrode, mm | 150…350 |
| (selected in accordance with equipment technological characteristics) | |
| The diameter of a cable of a tool electrode working part*, mm | 0.1…0.4 |
| Operating density of abrush electrode | until 0.5 |
| Speed of the line feed of ahalf-finished product | 0.1…5 |
| Movement of a tool electrode and a half-finished product | Opposite, following |
| Treatment time | Depend on the geometry of the original profile and sizes of the treatment item |
In particular cases during the roughing work of the products with high hardness and nonuniformity of the original profile, the diameter of brush electrode wires may be up to 0.8 mm.

8. Conclusion
In the article a sequence of calculation of modes for final treatment by means of the unshaped brush electrode is shown: electrode voltage, values of wire and blank part beams clamping, brush electrode supply, selection of the working medium [5]. The paper presents the recommended values of calculation that allows one to specify reasonable treatment modes.

References
[1] Kirillov O.N. 2010 Technology of combined treatment by means of unshaped electrode. (Voronezh: VSTU)
[2] Smolentsev E.V. 2005 Designing of electrical and combined methods of treatment (Moscow: Mechanical engineering)
[3] Kirillov O.N. 2010 Reporter of Voronezh State Technical University. 6(9) 91-94
[4] Baron Y.M. 1986 Magnetic abrasive and magnetic processing of products and cutting tools. (Leningrad: Mashinostroenie)
[5] Smolentsev E.V. 2005 The planning of electrical and combined processing methods. (Moscow: Mashinostroenie)