Abstract: The article deals with mathematically modelling relations of technological parameters and quality parameters. Competition and scientific progress requires introduction of technologies that perform challenging claims of modern production in automation field, from economy, environmental and energy efficiency point of view. Nonconventional cutting methods represent all of these claims. The EDM machining techniques are considered to be flexible tools in the processing of a wide range of materials without time loss by tool changing. In spite of great research effort and good knowledge in the field of progressive methods of cutting, there are still number of unexplained facts. One of them is influence of process factors on workpiece surface quality. Key words: WEDM, hardware, quality, mathematical model, optimalization

1. INTRODUCTION

New developed materials by space age technology sometimes cannot be economically cut using conventional cutting tools. Special, super-hard materials, normally quite expensive, are required. The process wastes very little workpiece material due to its small kerf size, coupled with the fact that the process can accurately cut unusual shapes. In modern manufacturing industry, WEDM has been extensively used to machine complicated shapes on advanced materials with high accuracy. WEDM is complex in nature and controlled by large number of parameter. Figure 1 shows the deterministic factors responsible to the wire EDM performance.

EDM removes workpiece materials by harnessing thermal energy produced by pulsed spark discharges across a gap between tool and workpiece. A spark discharge generates a very small plasma channel having a high energy density and a very high temperature (up to 10.000°C) that melts and evaporates a small amount of workpiece material. The spark discharges always occur at the highest electrical potential point that moves randomly over the machining gap during machining. With continuous discrete spark discharges, the workpiece material is uniformly removed around the tool electrode. The gap size in EDM is in the range of 400° in. to 0.02 in. (0.01 to 0.5 mm), and is determined by the pulse peak

![Diagram settings of technological parameters by electroerosion cutting](image-url)
voltage, the peak discharge current, and the type of dielectric fluid. \[^7\]

2. CHARACTERISTIC OF TECHNOLOGICAL DEVICE OF TECHNOLOGY EDM

All operation needs to cutting specimens for experiment was performance to machine AGIECUT 200D visible in fig. 1.

Fig. 2 Electroerosion equipment AGIECUT 200D

3 EXPERIMENT CONDITIONS – PRODUCTION SPECIMENS

3.1 Workpiece material
Specific properties of the workpiece material also influence the process. These properties include how well the metal is polished, its magnetic condition, and how the metal was removed from the heat treatment process when it was produced. One must also consider expansion and contraction according to the temperature of the material. For material processed by EDM or WEDM, the initial surface condition affects the results. A low melting point in the material increases the MRR, and improper heat treatment of the metal results in distortion and breakage of the mold. \[^1,3\]

3.2 Influence of wire material characteristics
By the means of examining these properties, desirable wire materials for WEDM electrodes should be:

- Adequate tensile strength with high fracture toughness
- High electrical conductivity
- Good flushability
- Low melting point
- Low energy requirement to melt and vaporize

<table>
<thead>
<tr>
<th>Main of technological parameters</th>
<th>Range of adjustment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate of speed &quot;(v_f)&quot;</td>
<td>(0.5 \div 10 \text{ mm.min}^{-1})</td>
</tr>
<tr>
<td>Distance pulse duration &quot;(t)&quot;</td>
<td>(1 \div 10 \mu s)</td>
</tr>
<tr>
<td>Working current cutting &quot;(I)&quot;</td>
<td>(0 \div 20 \text{ A})</td>
</tr>
<tr>
<td>Working of performance cut &quot;(P)&quot;</td>
<td>(0 \div 1 \text{ kW})</td>
</tr>
</tbody>
</table>

Tab. 1 Volume of technological parameters at production specimen by technology EDM \[^3\]

4. EXPERIMENT EVALUATION

On basis measure out data using program EXCEL function logarithmic regression LOGEST, they were specified equation 3D dependence, so result was amount field parameters, which this surface interprets. General figure of mathematical model into all case have form:

\[
z = b \cdot m_1^x \cdot m_2^y \cdot m_3^z \cdot m_4^x \cdot m_5^y \cdot m_6^z \cdot m_7^x (1)
\]

where dependent variable \(z\) is function independent variable \(x\) and \(y\), values \(m\) until \(m_7\), which respond to single value exponent \(x\) and \(y\), as \(b\) is constant value.

4.1 Application general form mathematical model on rate of speed and surface roughness parameters
Mathematical model 3D dependence working current cutting \(I\) on required roughness surface \(Ra\) at given thickness material calculated by program EXCEL logarithmic regression can be write in form \[^3\]:

\[
I = 0.039 \cdot 1.012^R \cdot 0.999^R \cdot 1.00000083^R \cdot 45.265^R \cdot 0.271^R \cdot 1.192^R \cdot 2 (2)
\]

coefficient correlation is \(R^2 = 0.9897\) \(^2\)
where:
I – working current cutting [A]
H – depth of cutting material [mm]
Ra – surface roughness [µm]

- Register calculation of technological parameters
- Graphic presentation of technological parameters
- Print technological parameters
- Data archives
- Stop program

Fig. 3 3D dependence surface roughness on value working current cutting and depth of material cutting

5. SOFTWARE FOR SIMULATION OF TECHNOLOGICAL PARAMETERS

Designed software CNC TP simul WireEDM for simulation influence of technological parameters on quality surface cut serve, than supporting software to program for control all process of production in technology EDM. This software exist is basic on functional dependence main technological parameters on surface roughness cutting. Software main function is calculate and graph view optimalization values of technological parameters near required quality – i.e. surface roughness cut. Steps of simulation software:
- Start program
- Main menu
- Setting sort products
- Setting diameter
- Setting thickness of cutting H
- Setting surface roughness Ra
- Calculation total time
- Calculation cutting costs
- Mathematical calculation

Fig. 4 View of software CNC TP simul WireEDM representative calculation technological parameters

Following table shows comparison simulation and experimental values technological parameters, roughness surface, total cutting time and cutting costs at production shear tool.

<table>
<thead>
<tr>
<th></th>
<th>Simulation value</th>
<th>Experimental value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rate of speed “v” [mm.min⁻¹]</td>
<td>1.18</td>
<td>1.20</td>
</tr>
<tr>
<td>Distance pulse duration “t” [µs]</td>
<td>4.25</td>
<td>4.25</td>
</tr>
<tr>
<td>Working current cutting “I” [A]</td>
<td>2.67</td>
<td>2.70</td>
</tr>
<tr>
<td>Working of performance cut ”P” [kW]</td>
<td>0.29</td>
<td>0.30</td>
</tr>
<tr>
<td>Roughness surface Ra [µm]</td>
<td>2.20</td>
<td>2.23</td>
</tr>
<tr>
<td>Total cut length [mm]</td>
<td>250</td>
<td>250</td>
</tr>
<tr>
<td>Total cutting time</td>
<td>3 h 32 min</td>
<td>3 h 28 min</td>
</tr>
<tr>
<td>Total cutting cost €</td>
<td>46.60</td>
<td>46.60</td>
</tr>
</tbody>
</table>

Tab. 4 Comparison simulation and experimental values

Comparison simulation and experimental values was determined difference in asking and acquirement value roughness surface 0.02 µm which is much good.
6. CONCLUSION

This article describes experimental statement of function dependence between main technological parameters and parameters quality in electroerosion metal cutting operation by technology EDM. Introduce demonstration software CNC TP simul WireEDM for simulation influence of technological parameters (rate of speed, working current cutting, working of performance cut and distance pulse duration) on surface roughness cutting face. The software presented allows increase efficiency in process programming and adjustment parameter machine for electroerosion metal cutting. The main economic addition to expects in abbreviated production time, increased cutting quality by reduced number of waste at machine setting on new production program \[4,5,6\].

7. REFERENCES

2. Straka, L. Control quality in EDM machined In: 2. seminary PhD student.

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