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MODELLING AND SIMULATION OF THE INFLUENCE OF BASIC TECHNOLOGICAL PARAMETERS IN EDM MACHINING

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ABSTRACT:
This paper presents modelling and simulation of the influence of basic technological parameters on quality parameters in EDM cutting process. The model was established on the basis of experimental measurements, and was verified on particular products. Presented model should serve as one of partial modules for assembling of complex control software assigned for technological parameters optimization in steel cutting with EDM (Electrical Discharge Machining) progressive cutting technology.
KEYWORDS:
simulation, optimization, software, basic technological parameters.

1. INTRODUCTION

Character of eroded cutting surfaces is comparable with surface quality achieved by the finest horizontal spindle surface grinding machines. Ground surfaces are glossy nevertheless their roughness might reach higher values compared to eroded (matte) surfaces. [1] The contribution deals with determining of the course of a heat affected zone under surface of samples made by WEDM cutting with brass electrode.

2. ANALYSE OF BASIC TECHNOLOGICAL PARAMETERS INEDM PROCESS

Overall review of basic technological parameters of WEDM cutting with wire electrode, were affected microstructure along with parameter range and its influence on the cut quality is shown in table 1 - 4.

Rate of feed v_f

Rate of feed has significant influence on cut surface quality. High rate of feed can cause wire deviation from ideal position, the deviation depends on cutting edge height. The higher the cutting edge height, the bigger the deviation. [2]Compensation is carried out by special electric means: against cutting force one more anti-force is incorporated. Cutting speed is then selected depending on material, cutting edge height and wire diameter.

Table 1. Influence the rate of feed on the haz in wedm technology

Technological parameters	Setting-up range	Impact on HAZ
Rate of feed "*vf*"	usual 0.5÷10 m.min^{-1}	Electroerosion process must be respected, with growing rate of feed roughness grows and heat- altered zone decreases.

Pulse duration *t*

Pulse duration in which one discharge is carried out has influence on roughness and cut width, and shows together with current amplitude an optimum that does not depend on workpiece material and cutting height. [3] Greater *t* value means higher rate of feed, increased surface roughness, and wider cutting gap.

Table 2. Influence the on time pulse on the haz in wedm technology

Technological parameters	Setting-up range	Impact on cut quality
ON time pulse "*t*"	1 ÷10 µs	With "*t*" increase roughness grows, cutting gap extends, cutting speed and HAZ increases.

As the set value is increased, the peak current level becomes higher to increase the cutting rate. However, the surface roughness and discharge gap are degraded accordingly.

OFF time pulse *td*

With decreasing the set value off-time pulse the cutting rate is improved but the possibility of wire breakage becomes higher and depth of heated grows. [4]

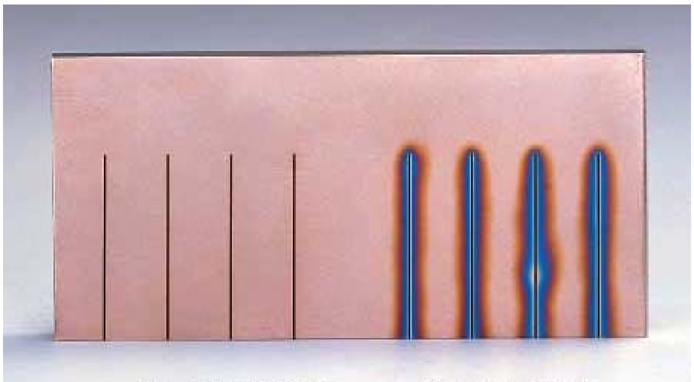
Table 3. Influence the off time on the haz in wedm technology

Technological parameters	Setting-up range	Impact on HAZ
OFF time pulse "*td*"	1 ÷20 μs	With growing "*td*" shape inaccuracy and HAZ degraded.

Working cutting current *I*

Working cutting current *I* has direct influence on roughness and cut width. Working current increase causes increased surface roughness and extension of cutting gap [4].

As the set value is increased, the discharge gap and HAZ become larger. Working cutting current value has striking impact also on heat-altered zone depth. Current increase has negative influence on heat-altered zone depth, that can-depending on current value-range between 5 to 20 μm. [5]



a) lower discharge current b) higher discharge current

Figure 1. An influence of working current on haz

Table 4. Influence the working cutting current on the haz in wedm technology

Technological parameters	Setting-up range	Impact on HAZ
Working cutting current "I"	0 ÷ 20 A	With increasing current value surface roughness grows, cutting gap extends and depth of heat- altered zone grows.

3. CUTTING HAZ QUALITY APPRAISAL

Under the melting surface layer there is a heat affected zone in which structural changes take place. Depth of this zone depends on initial structure of cut material and on character of phase change that took place during the cutting process. [6]

Overall depth of WEDM impact on yet unmachined surface ranges from 10 to 30 μm. The deepest affected zone occurs at WEDM cutting of hardened carbon steels. Alloy steels render considerably lesser affected zones. Materials that need long holding times on high temperatures for structural changes to take place shows only inconsiderable depth of heat affected zone at WEDM cutting. [5]

4. EXPERIMENTAL MEASUREMENT DEPTH OF HAZ

Real values of depth and amount of heat influence can be achieved by the measurement of micro-hardness in affected zone on sample surface. Small depth of affected zone (10 to 30 μm) generates a problem in micro-hardness measuring method. The best method appears to be the method of oblique section. The principle of the method is based on metallographic polished section at a very small angle α. [7]

The sample was made from steel EN ISO 9679 X210 CR12. Hardness test according ISO 6507 was applied for micro-hardness measurement. Stabs were done by steps from an edge of the section to material interior untill micro-hardness value stabilized on its constant value equal to basic material hardness (app. 750 HV2). [6]

Character of heat affected zone depends significantly on type of work, applied output power, and adjustment of cutting process parameters. The sample on figure 3 illustrates situation in the condition of first cut. For all samples following initial conditions were applied:

- wire diameter ϕ 0.25 mm

- brass wire of cutting (Ms 63)
- material of specimen X 210 CR12

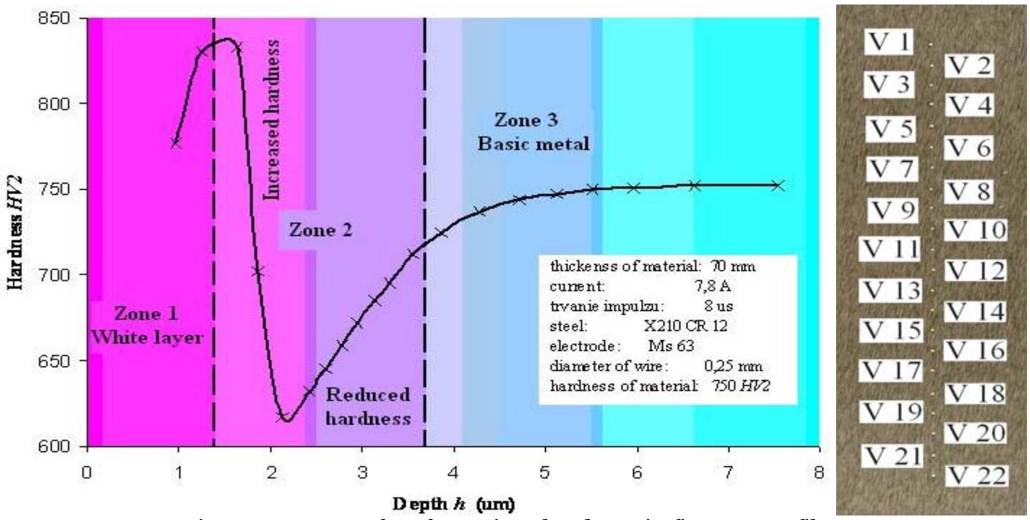


Figure 3. Course of surface micro-hardness in first cut profile

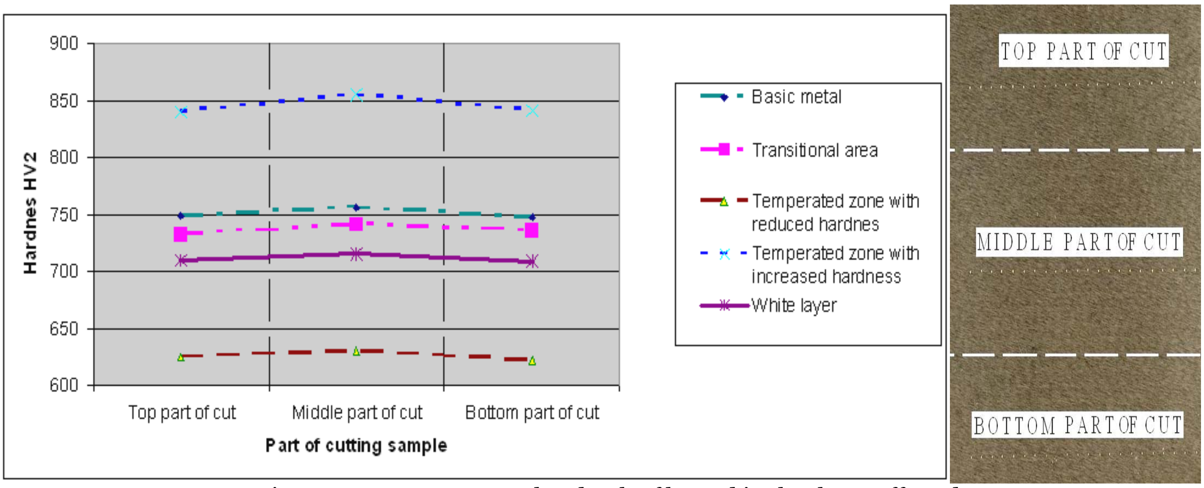


Figure 4. Measurement value depth of heated in the three affected zone

5. EVALUATION OF THE HAZ

Experimental observation of heat affected zone shows different depths of impact in particular levels and directions of the cut. In first case the course of affected zone in cutting tool (wire) axis direction was observed, in second case the direction was perpendicular to wire axis in three levels.

First level was in top part of the cut, second level in middle part of the cut, and third level in bottom part of the cut. Top and bottom profiles of the cut rendered approximately the same depth and hardness of subsurface layer [6]. In thorough evaluation the conclusion is that micro-hardness should be measured in direction of wire movement hence in direction perpendicular to wire axis. Otherwise the measurement will be affected by middle part of the cut in which the impact is about 2-3 % higher than at the edge of the cut.

6. CONCLUSIONS

To produce effectively and in good quality is a target of any manufacturing process. Among important requirements imposed on manufacturing belongs product accuracy. WEDM technology distinguishes by high production quality. This fact apparently relates to the high automation degree of the technological process control.

Quality appraisal of EDM wire-electrode cutting products is a complex process too. To judge the quality objectively we must come out from basic principles and specifics of the technology. Concerning

EDM technology end-products, above all roughness, surface hardness, and depth of heat-altered zone are appraised.

Surface hardness change determination is in particular important at shearing tools manufacturing, where EDM is rather often applied. [8] Surface hardness reduction by electroerosion process decreases operational life of these tools. The undesirable phenomenon can be up to a certain limit eliminated by the optimal selection of technological parameters.

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