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MATHEMATICAL MODELLING OF PLASMA ARC CUTTING TECHNOLOGICAL PROCESS

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ABSTRACT
The article presents the design and evaluation of plasma arc cutting technological process. Influence of technological factors on roughness parameters Ra of the steel surface ISO Fe510 have been evaluated using planned experiments. Using factor experiment 24 , the significance of the four process factors: plasma burner feed speed, plasma gas pressure, nozzle diameter, distance between nozzle mouth and material have been observed. Regression models obtained by multiple linear regression indicates the quality level as observed factors function.
Keywords: plasma arc, factor analysis, quality

1. INTRODUCTION
A lot of authors think, that the plasma is some elements of ionosphere, especially film F, which resists radiophare wavepath bounce to ionosphere. Plasma is in the van Allen radiating line.

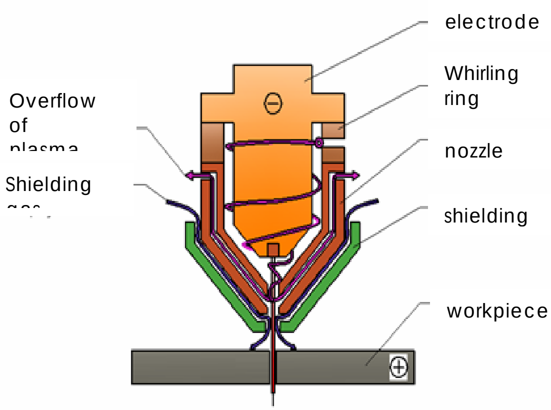

Figure 1. High definition plasma cutting

The sunny wind, the non/stop ampere of the elements from our sun, in which our Earth is too, it is the plasma again. In the plasma's state are nitra, the nucleus of the nebulas and a lot of subjects in the cosmos. Underfoot we meet with the plasma in the lines of bolts, by different discharges and plasma is producing imitation and it's search into the research laboratory too. Plasma is the fourth and most highly energized state of matter: solid, liquid, gas and then plasma. In fact, plasma looks and behaves like a high-temperature gas, but with an important difference - it conducts electricity. The plasma arc results from electrically heating a gas (typically air) to a high temperature. This ionizes gas atoms and enables them to conduct electricity. A fluorescent light is an example of plasma in action. A plasma arc torch spins a gas around an electrode. The gas is heated in the chamber between the electrode and torch tip, ionizing the gas and creating plasma. This causes the plasma gas to expand in volume and pressure.

2. ADVANTAGES AND DISADVANTAGES OF PLASMA CUTTING

Advantages:

- better cut quality when cutting thick materials (compare to flame cutting)
- cheaper than laser for cutting of thin sheets
- low impact of working environment
- suitable for thicker sheets with medium demand on cut edge quality and correctness
- high cutting speed (depends on material thickness)
- possibility of reaching good surface roughness for steels and anticorrosion steels
- simple replacement of throat, electrode, torch
- relatively wide thickness extent of cut materials

Disadvantages

- noise level raises with raising of current
- cannot create neither little rounds of cut edge nor strait grooves
- serious cut width
- different cut quality /bad side gets to waste)
- harmful steams ensuing (exhausting needed)

3. CONDITIONS OF EXPERIMENT PLANNING

The process parameters are caused in common interactivity in praxis with plasma cutting. For the analyzing of this model are used factors experiment. This experiment evaluates combinations of all planning factors. As experimental material was constructional steel ISO Fe510 with 6 mm thickness and the plasma gas was air. We made 16 pieces of samples.

Factors:

- nozzle diameter,
- plasma burner feed speed,
- plasma gas pressure,
- distance between nozzle mouth and material.

Table 1. Table of real level values of factors of experiment

N.	Factors			Interval of factors	
	Marking	Description	value	-1	+1
1	x_1	nozzle diameter (d)	mm	1	1,2
2	x_2	plasma burner feed speed (v)	m/min^{-1}	0,6	0,9
3	x_3	plasma gas pressure (p)	MPa	0,55	0,68
4	x_4	distance between nozzle mouth and material (z)	mm	6,6	7,8

In this example we have four factors, it is thus tetradimensional model. By two levels of different factors, where particular levels are coded as –1 and +1 it presents full factor of 2^k type. Than for four factors particular attempts will be realized in 2^4 = 16 different relations. Such two-leveled factor experiment will be used for simple specification of factors, that statistically significantly impact the variability of values of variables y_{Ra}, y_{Rz}, y_{δ}.

By the exact test that besides main factors includes also interactions off all combinations of factors and levels, there can be investigated the impact of all potentially possible combinations of factors and after elimination of statistically not-signified factors it can be moved to more detailed and accurate experimental schemes. To the coded values of –1 and +1 levels, that present the level of observed area of particular factors, there have been assigned real level values of these factors. (Table 1).

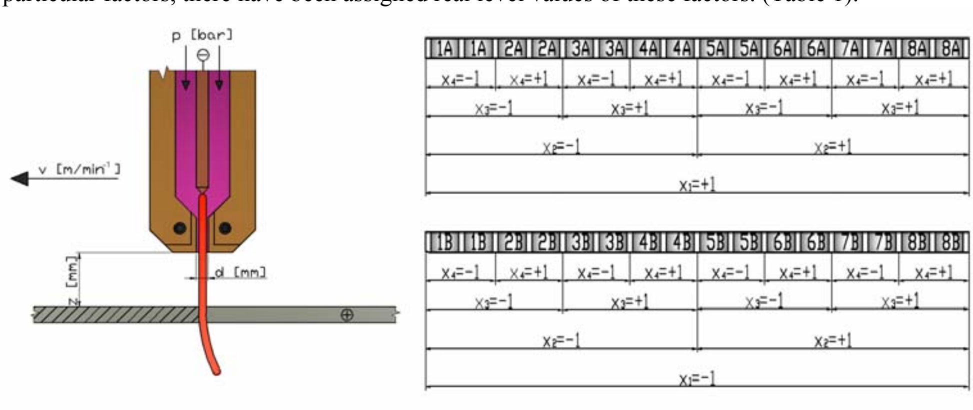

Figure 2. The process parameters and factor analysis

The roughness was measured in two lines, one and five millimeters from upper edge. Measurement was realized by apparatus Mitutoyo . Roughness of surface is create by anomalies of surface with small separation, which are including anomalies from the different technology of manufacturing or another effects. We suppose that these anomalies are within defined borders, for example in border of primary length.

3.1. Measurement in first line

Signification of bearing for monitored factors to parameter of roughness **Ra in distance one millimeter** from upper edge is shoved in Paret´s graph (Figure 3.).

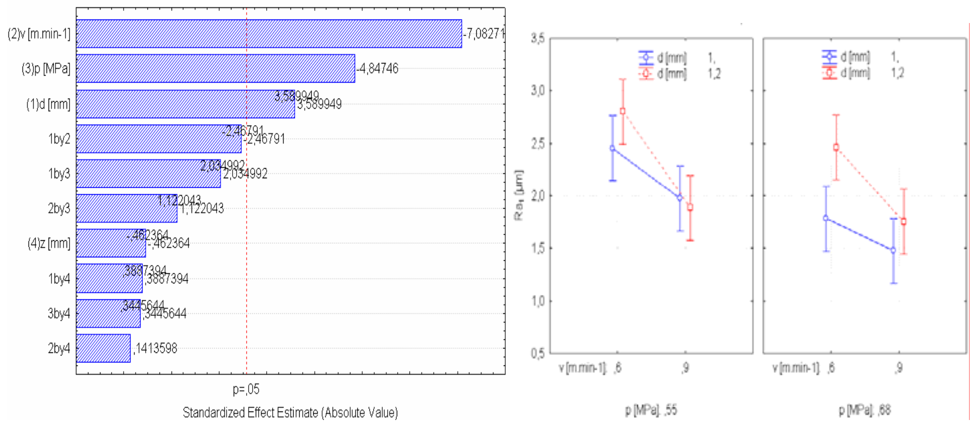

Figure 3. Paret´s graph for distance one millimeter from upper edge

The result from Paret´s graph is the most influence for the roughness Ra factor of the plasma burner feed speed. From Paret's graph it is obvious, that highest impact to middle arithmetical deviation of surface roughness has the feed factor of plasma torch. Significant impact to the quality of machined surface has also the pressure of plasma gas. Lower impact to the quality presents the nozzle diameter. Lowest impact is presented by distance of nozzle mouth from material. After realization of hypothesis about importance of particular equations coefficients and elimination of not-signified factors out of linear regression, final equation was acquired, that express the middle arithmetical deviation of Ra profile in relevant measured depth h = 1 mm.

3.2. Measurement in second line

Signification of bearing for monitored factors to parameter of roughness **Ra in distance five millimeters** from upper edge is shoved in Paret´s graph (Figure 4.).
From Parent's graph it is obvious, that highest impact to the middle arithmetical deviation of surface roughness has feed factor of plasma torch. Significant impact has also the pressure of plasma gas. Minimal impact level is presented by nozzle diameter and distance between nozzle mouth and material.

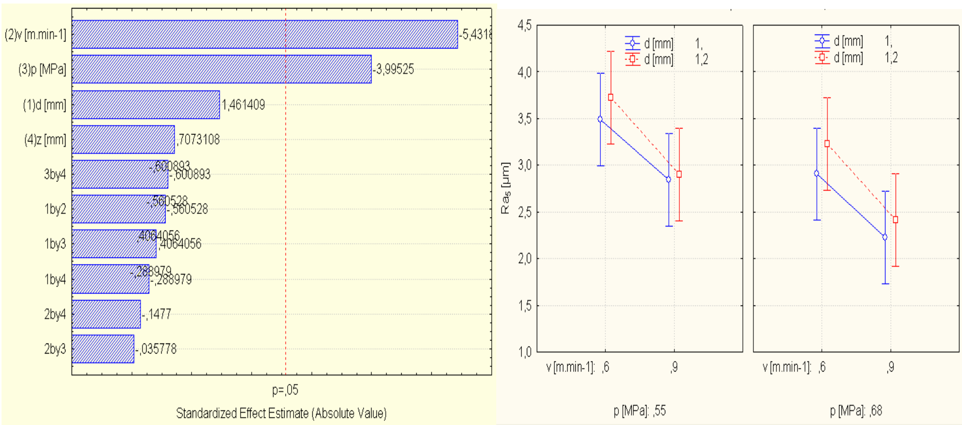

Figure 4. Paret´s graph for distance five millimeter from upper edge

4. CONCLUSION

Paper deals with definition and evaluation of process factors and parameters of cut surface while cutting the material ISO Fe510. Methods of planned experiments are used for these evaluations. Using factor experiment, importance of four factors was observed (feed rate of plasma torch, plasma gas pressure, nozzle diameter and distance between nozzle mouth and material), that influence the parameter of roughness profile Ra and Rz. On the base of results that were analytically processed by factor analysis it can be said, that impact of process parameters during the material cutting was different in particular depths. It was found out, that most significant impact to the machined surface roughness have factors of feed rate of plasma torch and plasma gas pressure. Among other factors that are less important belongs diameter of nozzle and distance between nozzle mouth and material. From the experimental results it can be said, that for achieving higher quality of cut surface it is recommended to use higher pressures of plasma gas and appropriate feed rate of plasma torch.

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