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THEORETICAL AND EXPERIMENTAL CONTRIBUTIONS ON THE USE OF PLASMA ARC INSTALLATIONS IN CUTTING DIFFERENT TYPES OF MATERIALS - PART 2

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***Abstract**: The aim of this study is to assess the proper technological parameters of plasma cutting in different materials. By measuring the outcome surface roughness values, it was assessed both the influence of technological process parameters and the type of plasma cutting device upon the cutting speed and cut surface quality. By carrying out the experiments at the Technical University of Cluj-Napoca and in some production facilities, and by using ANOVA method (used for mathematical models testing) and The Response Surface Methodology, the present study has conducted to the following final benefits: practical recommendations concerning the optimization of the technological parameters; decrease of the costs and increase of the consumable items life-time. Upon these results, a data base will be achieved and implemented to extend the technological capabilities of the existing plasma-cutting plants.*

***Keywords**: Plasma Arc Cutting, Measurement of roughness on the cut surfaces, Response Surface Methodology*

1. INTRODUCTION

1.1 Factors affecting consumable life

In a properly functioning system, three key factors affect consumable life (The Hypertherm, sept. 2000): number of pierces, cut duration and material thickness.

These technologies by themselves, however, do not guarantee optimal consumable life. Other system problems still can cause unnecessary consumable wear. In most instances, these operating problems are fairly easy to identify and correct: premature or improper consumable changeout, pierce height, ramp-down errors in oxygen cutting systems, gas supply, coolant flow, and work cable connection.

2. CONTRIBUTIONS ON NUMERICAL OPTIMIZATION OF THE PLASMA ARC CUTTING PROCESS

2.1 Numerical optimization. Desirability values.

When studying material *Stainless Steel*, steel grade 5NiCr180, thickness 3 mm, it is designed to achieve optimization with the condition of minimum roughness (Fig. 1) and minimum cutting time (Fig. 2), regarding the degree of optimization, the points of prediction are 0,731 and 0,976.

Following the value curves indicated in Fig. 3, it is easy to see that they are more inclined towards the speed axis than the voltage axis, therefore suggesting an increased influence of the cutting speed parameter.

Once the steps for optimization are went through, the program offers a solution to obtain the minimum roughness value using the data provided. To obtain a minimum roughness, Ra = 19,47 µm, and a cutting time value of t=15,21 s, the voltage must have the value of 170 V, the intensity 80 A and cutting speed of 975 mm/min.

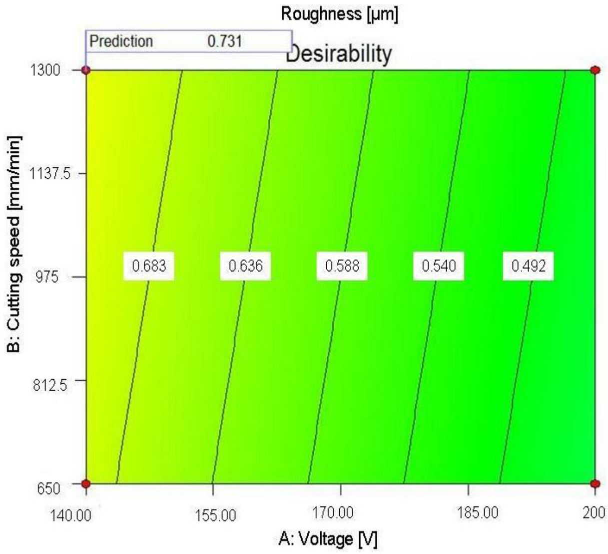

Fig. 1:. The chart for the objective function Roughness represented by curves of constant value depending on the electrical current voltage and cutting speed, material 5NiCr180 thickness 3mm

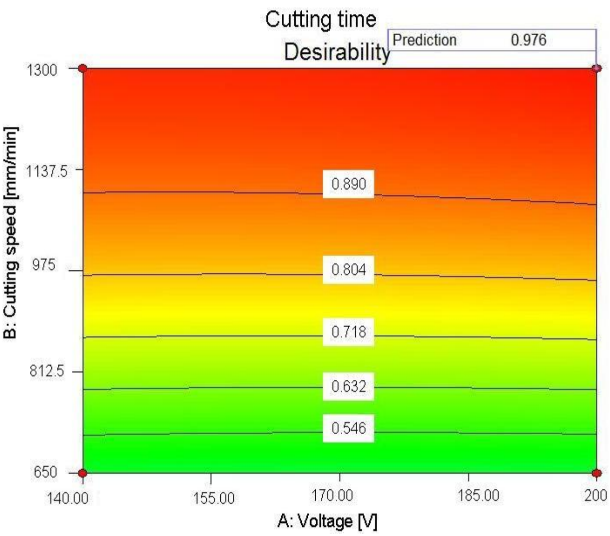

Fig. 2. The chart for the objective function Cutting time represented by curves of constant value depending on the electrical current voltage and cutting speed, material 5NiCr180 thck. 3mm

It is noted that in Fig. 1, 2 and 3 Desirability term is represented, whose value varies on a scale from 0 to 1 (1 being the maximum). For material 5NiCr180 thickness 3 mm, that point's value is 0.976.

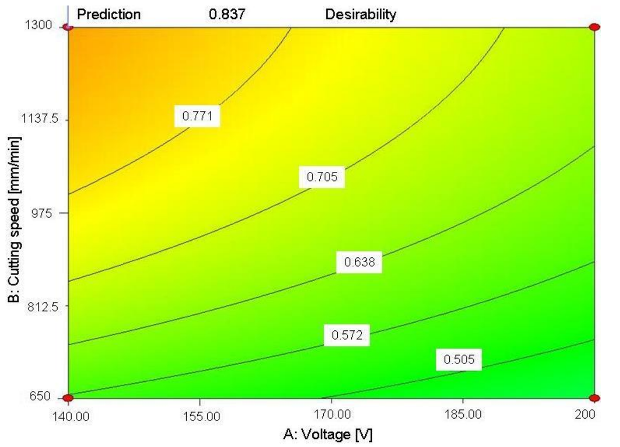

Fig. 3. The chart for the objective function Roughness and Cutting time

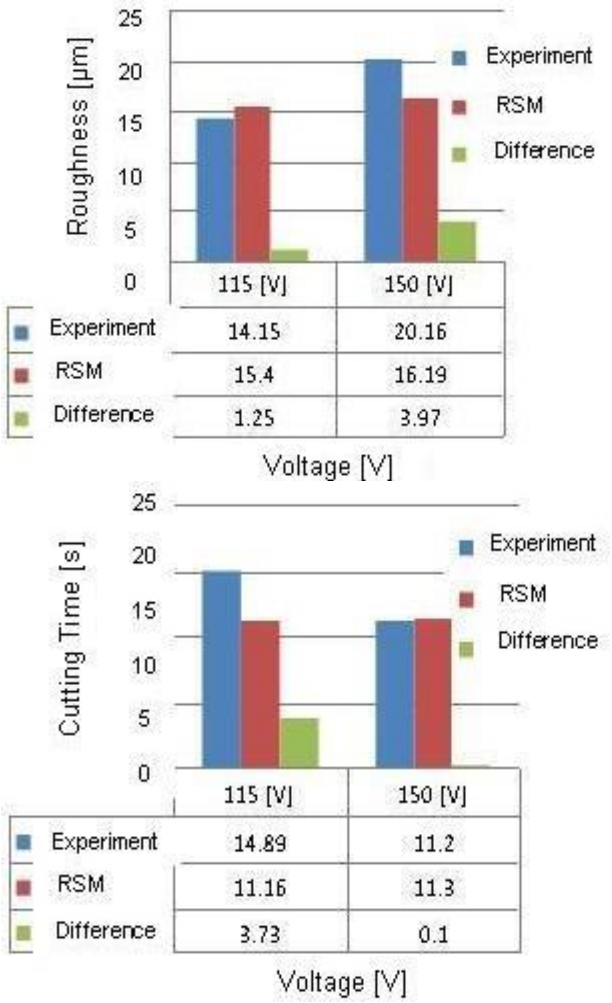

Fig. 4. Changes in roughness and cutting time through generator current voltage, material 5NiCr180 thickness 3mm

3. MATHEMATICAL MODELS RENDERING

A model rendering is a process of confirming that the model can approximate the outcome experimental values with a satisfactory level of accuracy. The main question is how to estimate the confidence level of a model. Mainly there are three techniques for validation of a model (Lăzărescu et al., 2008): by graphical comparison, confidence interval method, and R^2 method (the calculation of determination coefficient).

Graphic comparison method is based on visual comparison by the same graphical representation of experimental and calculated results.

Confidence interval method involves analysis of the model parameter uncertainty in the process of validating the model and determines the level of confidence of the calculated response.

4. FRAMING WITHIN THE CONFIDENCE INTERVAL

The calculated *F* statistics are compared with the reference value Fα (ν1, ν2), where ν1 represents the number of degrees of freedom in the numerator (of the considered factor) and ν2 the number of degrees of freedom of the error (in the denominator).

Analyzing the *F* statistics related to each mathematical model, (see ANOVA picture for response surface model for surface roughness and model of cutting time) in which the F (Fischer) statistic value is found, and considering the "Six Sigma philosophy" (Lăzărescu et al., 2008), it was determined that the probability that the results obtained with mathematical models to be within the confidence interval [-3σ, 3σ], is 99,95%.

5. CONCLUSIONS

It can be concluded that the material having a cut surface of the highest quality is undoubtedly steel grade S235JR (OL37-2k).

In terms of roughness, acceptable values (e.g. Ra = 5÷15µm) were found for stainless steel, studied alloy was grade 5NiCr180. The third group of examined material in the study was aluminum Al99.5. It describes, following the cutting process and performed measurements, the higher values of roughness which is interpreted as a poor cut surface quality.

After presenting the methodology for establishing mathematical models describing the relationship between quality characteristics (cut surface roughness and cutting time) and process variables (cutting speed, voltage and generator current intensity), the mathematical models were tested using the ANOVA method, and by graphical comparison it was demonstrated that the solutions fits sufficiently precise the experimental results.

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