CONTRIBUTIONS ON THE INFLUENCE OF THE PROCESSING PARAMETERS ON THE B WIDTH OF THE WELDING SEAM TO THE OPEN JOINT OF SHEETS BY FLUXSHIELDED ARC WELDING

Ilarion BANU, Nicolae POPA, Adrian BĂJAN
Universitatea din Piteşti

Abstract: *The paper presents the influence of the processing parameters (the welding arc voltage U_a, the welding current strength I_s, the rate of welding v_s and the feed rate of electrode v_e) on the penetration of the welding seam shape coefficient ψ, using the Taguchi method.*

Keywords: design process, design solution, functional design, structural design

INTRODUCTION

Studying the welding belts quality requires more and more the Taguchi method [1], [2], [4]. This method offers an instrument to study the welding belt quality loss and accordingly, the shape coefficient $\psi=B/h_p$ (the belt width in the cross section B/the welding belt penetration h_p). The FC chosen control factors are: U_a – the welding arc tension [V]; I_s – the welding intensity [A]; v_s – the progressive speed at welding [cm/min]; v_e – the progressive speed of the electrode wire [cm/min] (see table 1)

TABLE 1		**LEVELS**	
Control factors	**COD**	**-1**	**+1**
Natural measures			
The arc tension U_a, [V]	***Ua***	**28**	**38**
The welding current intensity I_s, [A]	***Is***	**500**	**650**
The welding speed v_s, [cm/min]	***Vs***	**112**	**168**
The electrode progressive speed v_e,[cm/min]	***Ve***	**120**	**160**

The signal/noise ratio has been computed in the following relation:

$$S/Z = -10 \cdot \log\left(\frac{1}{\overline{\Psi}^2}\right) \times \left(1 + \frac{3s_\Psi^2}{\overline{\Psi}^2}\right), \text{[dB]} \qquad [1]$$

With:

S – Signal;
Z – Noise;
$\overline{\Psi}$ – Arithmetical average of the measured values;
s_Ψ – Standard deviation of the measured values.

The effects [1], [2], [3]:

$\mathbf{E_{Ua[-1]} = M_{Ua[-1]} - M;}$
$\mathbf{E_{Ua[+1]} = M_{Ua[+1]} - M;}$
$\mathbf{E_{Is[-1]} = M_{Is[-1]} - M;}$
$\mathbf{E_{Is[+1]} = M_{Is[+1]} - M;}$
$\mathbf{E_{Vs[-1]} = M_{Vs[-1]} - M;}$
$\mathbf{E_{Vs[+1]} = M_{Vs[+1]} - M;}$
$\mathbf{E_{Ve[-1]} = M_{Ve[-1]} - M;}$
$\mathbf{E_{Ve[+1]} = M_{Ve[+1]} - M,}$ [1]

The interactions [1], [2], [3]:

I(Ua-Is-) = (Ua-Is-) - M - E(Ua-) - E(Is-);
I(Ua-Is-) = (Ua-Is-) - M - E(Ua-) - E(Is-);
I(Ua-Is+) = (Ua-Is+) - M - E(Ua-) - E(Is+);
I(Ua+Is+) = (Ua+Is+) - M - E(Ua+)- E(Is+) ş a m d, [1]

THE EXPERIMENTAL PLAN CHOICE

This is given in table 1 taking into consideration the conditions established in paper [3]

TABLE 2 With measured values for the shape coefficient ψ (EXPERIMENTAL PLAN L8(2^7)

The place for samples welding: METABET S.A. PITEŞTI;
the place for measuring : the TM laboratory of the TM department of PITEŞTI UNIVERSITY

The samples material: OL37-2K; the samples thickness: 12 mm;

The welding conditions: lease in I; the electrode wire thickness = Ø4mm;
The electrode wire brand S10Mn1; the flux brand FSM 37; the welding tractor1000 – TV – 4000;
the control factors values are established in table 1 [3] in conditions established in paper [3]

	The basic and Complementary Factors				Interactions			Measured values							-
I	**Ua**	**Is**	**Vs**	**Ve**	UaIs= VsVe	UaVs= IsVe	UaVe= IsVs	**Nr.1**	**Nr.2**	**Nr.3**	**Nr.4**	**Nr.5**	***Mean*** $\overline{\Psi}_i$	**Dev. STD** $(s_\Psi)_i$	**$(S/Z)_i$ [dB]**
1	-1	-1	-1	-1	1	1	1	2.66	2.58	2.83	2.87	2.49	*2.686*	0.161	8.535
1	1	-1	-1	1	-1	-1	1	2.08	1.56	1.9	1.46	1.86	*1.772*	0.255	4.706
1	-1	1	-1	1	-1	1	-1	1.87	1.86	2.24	1.9	1.92	*1.958*	0.159	5.750
1	1	1	-1	-1	1	-1	-1	1.4	1.6	1.21	1.66	1.88	*1.55*	0.255	3.465
1	-1	-1	1	1	1	-1	-1	1.26	1.46	1.29	1.28	1.28	*1.314*	0.082	2.321
1	1	-1	1	-1	-1	1	-1	1.52	1.4	1.5	1.46	1.58	*1.492*	0.067	3.449
1	-1	1	1	-1	-1	-1	1	2.29	2.47	2.31	2.36	2.58	*2.402*	0.121	7.578
1	1	1	1	1	1	1	1	2.03	2.32	1.94	2.11	1.97	*2.074*	0.152	6.266
The outpus (answers) general mean General mean: $M = \frac{\sum_1^8 \overline{\Psi}_i}{8}$; Average ratio $(\frac{S}{Z})_{med} = \frac{\sum_1^8 (S/Z)_i}{8}$													**M= =1.906**		**S/Z= =5.259**

THE ANALYSIS OF THE SIGNAL/ NOISE EFFECTS AND OF THE EFFECTS ON THE B WIDTH OF THE WELDING BELT AT SEF

TABLE 3 WITH THE COMPUTED VALUES OF THE EFFECTS ON THE ADJUSTED TECHNOLOGICAL PARAMETERS

The experiments Position number	***The effect on the ratio S/N***			***The effect on the measured value***	
	Factors	**S/N for the measured values**	**S/N [%] for the measured sizes**	**The measured sizes**	**The measured sizes, [%]**
1_3_5_7	***E(Ua-)=***	***0.787157***	***14.96754***	***0.184***	***9.653725***
2_4_6_8	***E(Ua+)=***	***-0.78716***	***-14.9675***	***-0.184***	***-9.65373***
1_2_5_6	***E(Is-)=***	***-0.50624***	***-9.62598***	***-0.09***	***-4.72193***
3_4_7_8	***E(Is+)=***	***0.506239***	***9.625979***	***0.09***	***4.721931***
1_2_3_4	***E(Vs-)=***	***0.355354***	***6.756947***	***0.0855***	***4.485834***
5_6_7_8	***E(Vs+)=***	***-0.35535***	***-6.75695***	***-0.0855***	***-4.48583***
1_4_7_8	***E(Ve-)=***	***1.202313***	***22.8616***	***0.272***	***14.27072***
2_3_5_6	***E(Ve+)=***	***-1.20231***	***-22.8616***	***-0.272***	***-14.2707***

On the tables 3 and 4 basis, the diagrams of the control factors influences are shown (see figure 1) for the S/Z ratio values and of the measured values (see figure 2) for the shape coefficient ψ welding belt width. And for the chosen interactions (see table 2) their values are computed using the measured values on the samples made of automatic electrical welding under a flux layer (see tables 2 and 3)

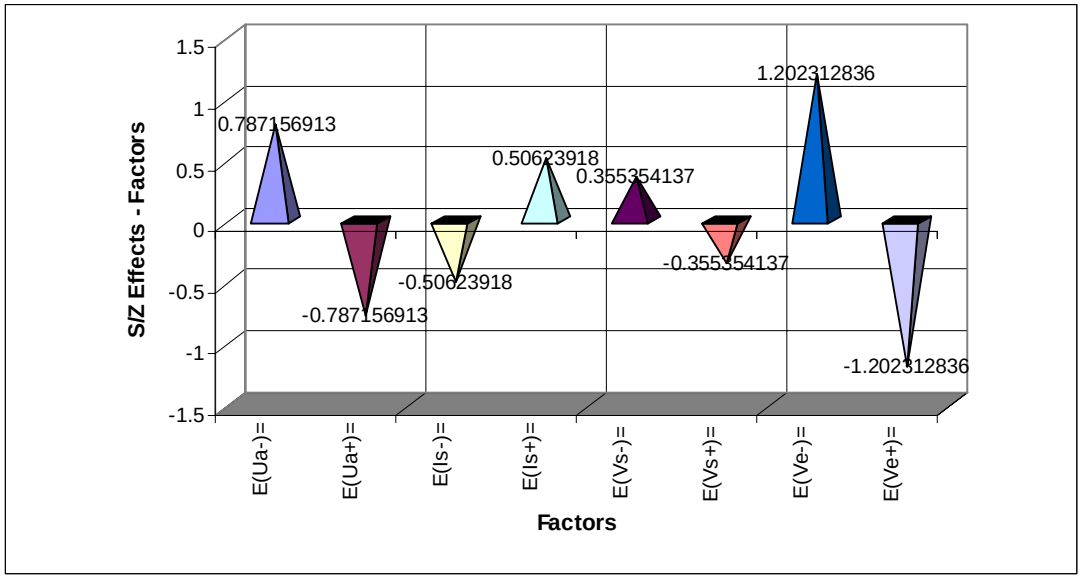

Fig.1 The adjusted technological parameters effect (U_a, I_s, v_s şi v_e) on the signal/ noise ratio For the welding belt shape coefficient ψ

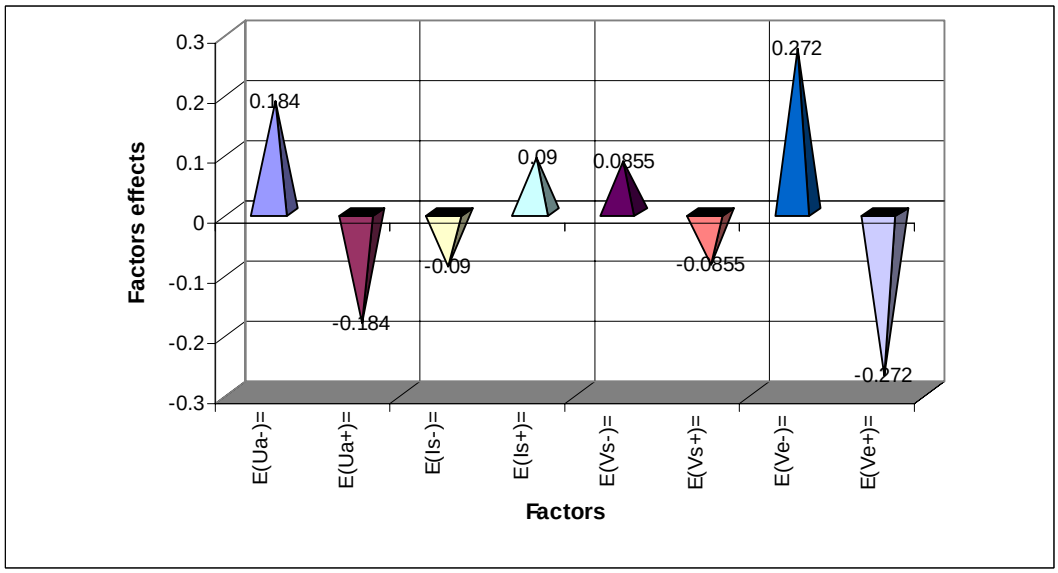

Fig.2 the adjusted technological parameters effects (U_a, I_s, v_s şi v_e) on the measured Sizes for the welding belt shape coefficient ψ

- In the case of the measured values (see fig. 2) we can see that these two parameters have the biggest values, but in a harder way, that would lead, for a beginner to make errors at the SEF welding system adjustment;
- The other technological parameters have smaller effects on the welding belt shape coefficient ψ

In this situation, the technological parameters $\mathbf{U_a}$ and $\mathbf{v_e}$ must be adjusted so their effects to be minimized to a central value ($U_a \approx 32V$, $v_e \approx 140$ cm/min)

Table 4 WITH THE EFFECTS COMPUTED VALUES ON THE ADJUSTED TECHONOLOGICAL PARAMETERS INTERACTIONS					
The experiments Position number	*The effect on the ratio S/Z*			*The effect on the measured value*	
	Interactions	**Interactions S/Z**	**Interactions S/Z [%]**	**The measured sizes interactions**	**The measured sizes interactions [%]**
1_5	***I(Ua-Is)-=***	***-0.111984521***	***-2.12935***	***0,9175***	***6,944182***
2_6	***I(Ua+Is-)=***	***0.111984521***	***2.12935***	***-0,9175***	***-6,94418***
3_7	***I(Ua-Is+)=***	***0.111984521***	***2.12935***	***-0,9175***	***-6,94418***
4_8	***I(Ua+Is+)=***	***-0.111984521***	***-2.12935***	***0,9175***	***6,944182***
1_3	***I(Ua-Vs-)=***	***0.741256464***	***14.09476***	***1,5675***	***11,86377***
2_4	***I(Ua+Vs-)=***	***-0.741256464***	***-14.0948***	***-1,5675***	***-11,8638***
5_7	***I(Ua-Vs+)=***	***-0.741256464***	***-14.0948***	***-1,5675***	***-11,8638***
6_8	***I(Ua+Vs+)=***	***0.741256464***	***14.09476***	***1,5675***	***11,86377***
1_2	***(Is-Vs-)=***	***1.512476517***	***28.75927***	***0,7225***	***5,468307***
3_4	***I(Is+Vs-)=***	***-1.512476517***	***-28.7593***	***-0,7225***	***-5,46831***
5_6	***I(Is-Vs+)=***	***-1.51248***	***-28.7593***	***-0,7225***	***-5,46831***
7_8	***I(Is+Vs+)=***	***1.512476517***	***28.75927***	***0,7225***	***5,468307***

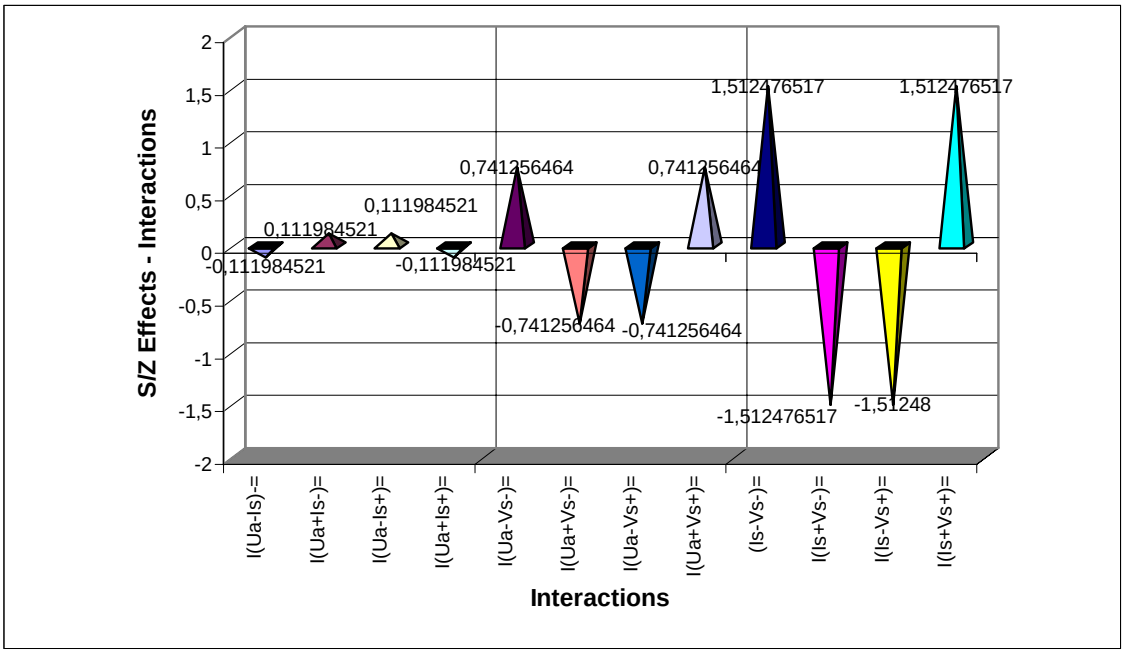

Fig.3 the adjusted technological parameters interactions (U_a, I_s, v_s şi v_e) on the Signal/ Noise ratio for the welding belt shape coefficient ψ

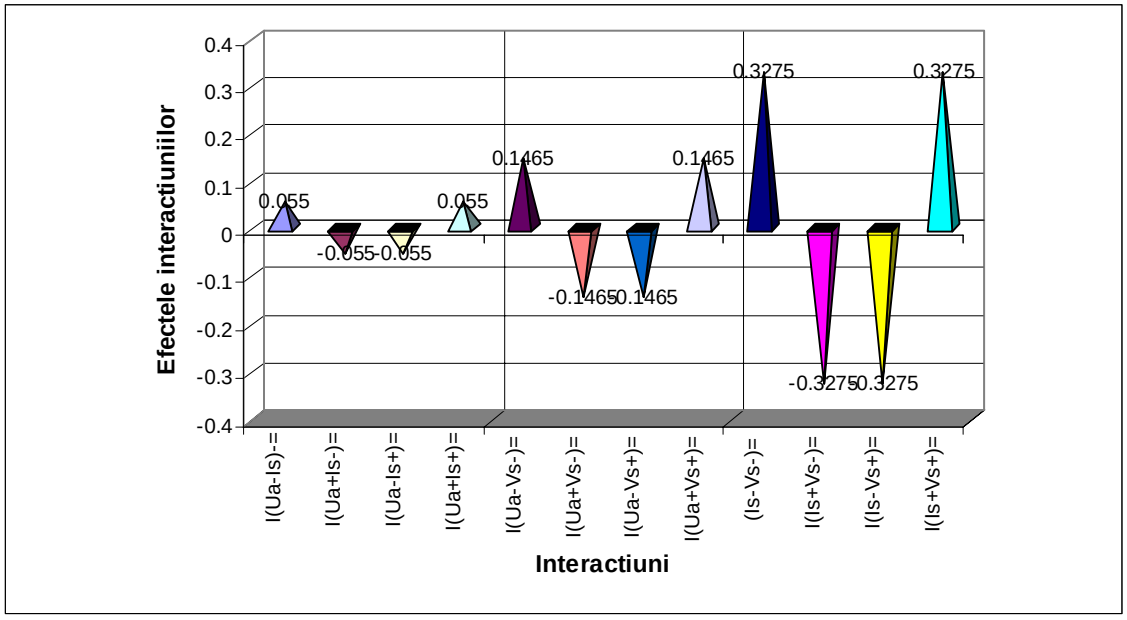

Fig.4 the adjusted technological parameters effects (U_a, I_s, v_s) on the measured sizes R for the welding belt shape coefficient ψ

Analyzing the signal/noise reports and the ones of the measured values for the adjusted sizes interactions (the basic and complementary factors) it results:

- The interactions groups (***UaVs***} and {***IsVs***} have strongest effect on the welding belt shape coefficient;
- These interactions are significant in order to establish a mathematical model in the case of the welding belt shape coefficient (see fig. 3);
- The measured values interactions (see fig. 4) give this information in a obvious way and this means that the classical method leads too to some good conclusions on these interactions and make evident other interactions effects.

The situation leads to these parameters adjustment to their central values (the arithmetical means of the values from table 1) in order to obtain valid solutions.
At the end of our short analyze we may approximate the width value with the equation (1) help:

$$\Psi = 1{,}906 + \begin{bmatrix} 0{,}184 & -0{,}184 \end{bmatrix} U_a + \begin{bmatrix} -0{,}09 & 0{,}09 \end{bmatrix} I_s + \begin{bmatrix} 0{,}0855 & -0{,}0855 \end{bmatrix} v_s$$
$$+ \begin{bmatrix} 0{,}272 & -0{,}272 \end{bmatrix} v_e + U_a^T \begin{bmatrix} 0{,}055 & -0{,}055 \\ -0{,}055 & 0{,}055 \end{bmatrix} I_s + U_a^T \begin{bmatrix} 0{,}1465 & -0{,}1465 \\ -0{,}1465 & 0{,}1465 \end{bmatrix} v_s$$
$$+ I_s^T \begin{bmatrix} 0{,}3275 & -0{,}3275 \\ -0{,}3275 & 0{,}3275 \end{bmatrix} v_s \qquad (1)$$

where: U_a, I_s, v_s, v_e are vectors; U_a^T şi I_s^T are the U_a respectively I_s vectors transposed.

Equation (1) can be used to create simulations on the electronic computer to obtain welding duties with valid solutions (almost independent from the noise factors)

CONCLUSIONS

We may say that:

- On the shape coefficient the biggest influence comes from the spring tension and the electrode advancing speed. In order to increase the Signal/ Noise ratio we can select : U_a = 38 V ; I_s = 575A, v_s = 140 = 140 cm/min ; v_e = 140 cm/min
- The interactions are big enough, so these parameters must take the mean value in order to obtain a stable solution.
- The relation (1) becomes :

$$\Psi = 1{,}9 + 0{,}184 + 0{,}09 + 0{,}08 - 0{,}272 + 0{,}146 + 0{,}32 = 2{,}45$$

These value is between ψЄ (1,5 3), which assure a wide belt for a big enough penetration [3], at the automatically electric welding process under the flux layer.

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