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WIG versus MAG – Neural Network Control

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Abstract

The improvement of the welding quality is achieved by the torch trajectory correction, based on following the welding joint, processing the acquired signals in the command system and modifying, if necessary, the welding parameters. He aim of the paper is to deal with the problem of using artificial neural networks in the welding process, respectively the use of adaptive linear filters in the command of the technological processes WIG and MAG welding, for controlling the position of the welding head, based on the analyze of the electric arc voltage.

Key words*:* *neural networks, control, welding, measurement, acquisition.*

Introduction

The final purpose of a welding operation is to achieve a welding seam that satisfies many imposed conditions. These conditions results from technological general system analysis, system composed by power source – welding source – arc welding system, welding seam, manipulation system and control system.

The paper present the way to process the welding-arc voltage with neural network. That result can be applied in automated robotic welding based on the corection of the trajectory welding torch through the welding seam.

Neural Network Welding Control

Using the anterior research, we have proposed a welding control system with neural network controller [3]. For welding head position control we use an acquisition system for arc voltage values from welding process. So, the arc voltage is a measure of welding head position.This signal will be the input for a neural network structure especially made by the authors for modifies the position of welding head.

This equipment may achieve real time control for algorithms of welding seam sensor, algorithm based on artificial neural networks - two interconnected adaptive linear filters: one filter work on interferences compensation principle and that filter extract the useful signal from welding process signal and the second one eliminate the error between reference signal and first filter output signal.

Experimental Stall

The process signal (fig. 1 and fig. 2) is obtained from a real WIG and MAG welding processes realized with an experimental stall, especially builder for that [2]. Characteristics:

- Electrical engine: MCC 12V.
- Welding source: LUD 450W ESAB ARISTO.
- Welding machine: AGA DW 22: 220V, 0.4 A, 50W.
- Welding process: a) **WIG** without addition material; wolfram electrode 2.4 mm; protection gas: argon; protection gas pressure: 10 bar; welding current: 65 A; welding voltage: 10...30V; advance speed: 70 mm/min; oscillation frequency: 0.5 Hz; oscillation amplitude: ±1.5 mm;
  b) **MAG**: power source: c.c.; welding process material: stainless steel 316; protection gas: 82% Ar + 18% CO_2; welding speed: 6m/min; oscillation frequency: 0.5 Hz; oscillation amplitude: ±1.5 mm.
- Process-computer interface: AX 5411.

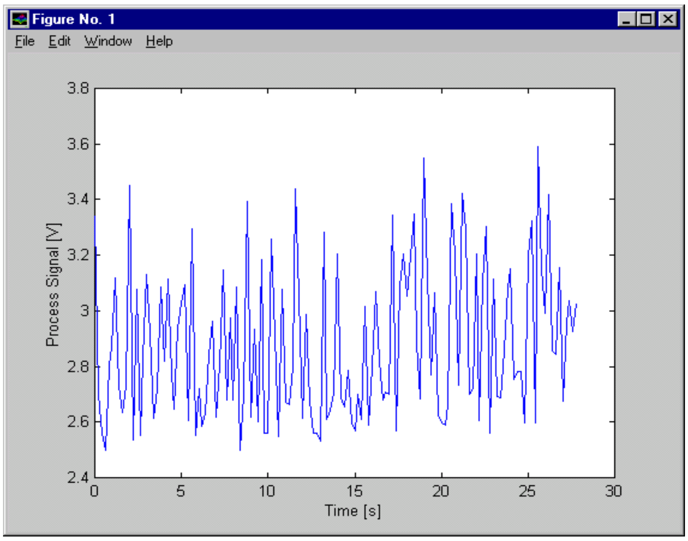

Fig. 1. The process signal for WIG welding.

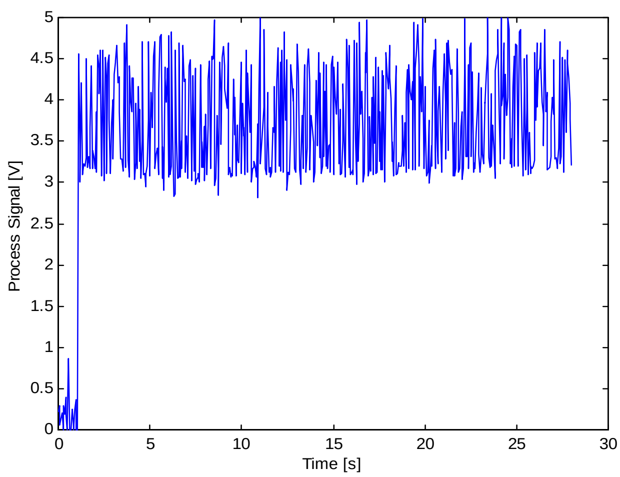

Fig. 2. The process signal for MAG welding

Analytical Computation of the Reference Signal

The reference signals are analytically calculated for a welding seam with the next dimensions: *L* – seam width – 1 mm; *d* – seam thickness = pieces high – 2.3 mm; *B* – distance from welding torch to the seam – 5.3 mm (fig. 3).

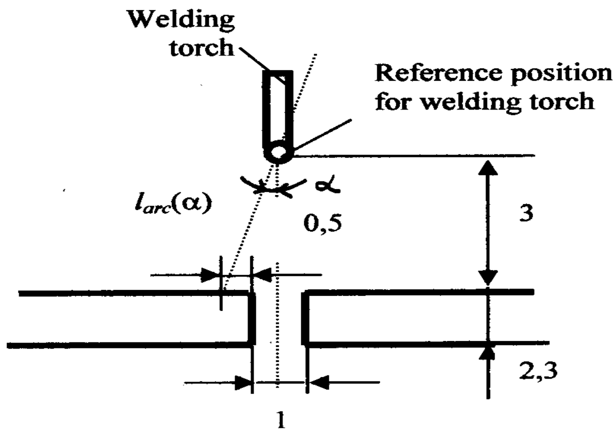

Fig. 3. Welding seam dimensions.

We know that the correspondence between the arc welding parameters: welding current I_S, arc voltage U_{arc} and length of electrical arc l_{arc}, for WIG welding processes is given by:

$$U_{arc} = a_1 I_S + a_2 + a_3 / I_S + a_4 l_{arc}. \quad (1)$$

For welding current I_S = 65A [4]:

$$U_{arc} = 8.412 + 0.3 \cdot l_{arc} \quad (2)$$

A function that approximates the configuration of U_{arc} is:

$$U^{*}{}_{arc}^{ref} = -0.13\sin(\pi t) - 0.07\cos(2\pi t) + 3.62 \ \text{[V]}. \quad (3)$$

We know that electrical arc voltage U_{arc}, for MAG welding, is calculated with [5]:

$$U_{arc} = a_1 I_s + a_2 + \frac{a_3}{I_s} + a_4 l_{arc}, \quad (4)$$

where l_{arc} is the electrical arc dimension and I_s - the welding current value. We will determine constants a_1-a_4 using the special diagram [5]. We obtain:

$$U_{arc} = 0.088 I_s - 1.866 + \frac{1260}{I_s} - 0.327 l_{arc} \ \text{[V]} \quad (5)$$

For the experimental welding parameters: welding voltage 20.6 V and welding speed 6m/min we obtain for welding current 216 A values. The relation (2) will be:

$$U_{arc} = 22{,}975 - 0.327 l_{arc} \ \text{[V]} \quad (6)$$

We can approximate this variation with the next function:

$$U^{*}{}_{arc}^{ref} = 0.078\sin(\pi t) + 0.042\cos(2\pi t) + 4.945 \ \text{[V]} \quad (7)$$

Neural Network Simulation

Neural network simulation was realized with the MATLAB program. For WIG processes, the designed references signal is obtained with the following sequence:

» time=0:0.2:27.8;
» x= - 0.13sin(πt) - 0.07cos(2πt) + 3.62 ;
» plot(time,x) ;
» p=[3.33984375
   2.69775390625...]…

For WIG processes, the designed references signal is obtained with:

» time=0:0.05:28;
» x=0.078*sin(pi*time)+0.042*cos(2*pi*time)+4.945;
» p=[0.22   0.30...];

The following program is similar for both welding types:

» t=x+p';
» [w,b]=initlin(p',t);
» [a,e]=adaptwh(w,b,p',t,0.00001);
» [w,b]=initlin(e,x);
» [a,e]=adaptwh(w,b,e,x,0.01);
» plot(time,a,time,x);

In these programs *x* is the reference signal, *p* is the process signal, *w* and *b* is adjusted weights, signal *a* is the output of neural controller and *e* is the error signal [3]. The output signals are presented in Figure 4 and Figure 5.

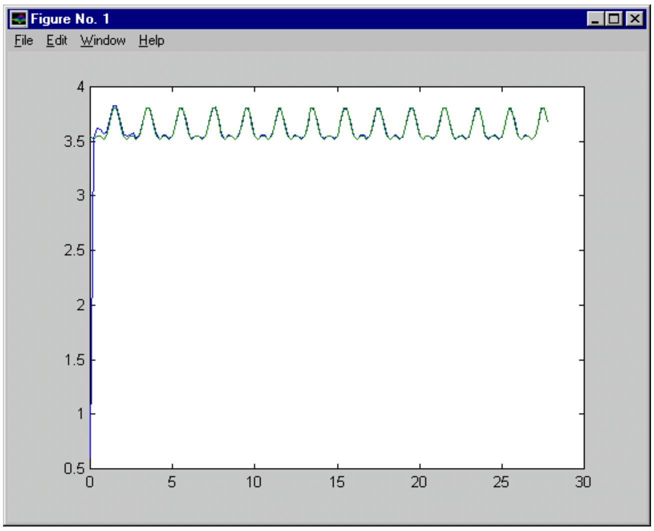

Fig. 4. Neural controller output over reference signal for WIG welding.

Conclusion

We observe that the error for WIG welding without addition material is small then error for MAG welding, because WIG welding process without addition material has easy modeled and the number of model parameters is not so big. For MIG-MAG welding processes appears the burned drop transfer phenomena thru the welding arc. These signals are commands for welding control had position.

These intelligent methods have been applied to control the behavioral characteristics of the welding process in order to improve quality and productivity in all industrial areas, especially a welding robotic area.

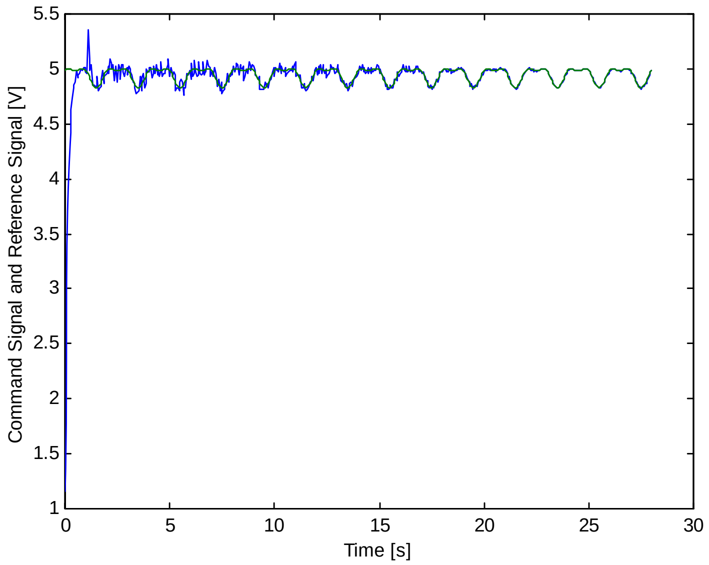

Fig. 5. Neural network output *a* over reference signal *x* for MAG welding.

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WIG versus MAG – Conducerea proceselor cu rețele neuronale

Rezumat

Îmbunătățirea calității îmbinării sudate depinde de corecția traiectoriei pistolului de sudare sau, modificarea, dacă este necesar, a parametrilor de sudare. Lucrarea prezintă o modalitate de corecție a traiectoriei pistolului de sudare, comparativă pentru cele două procedee WIG şi MAG. Traiectoria este controlată cu ajutorul semnalului de ieşire al unei rețele neuronale, alcătuită din filtre liniare adaptive, rețea ce consideră ca semnal de referință tensiunea arcului electric în timpul procesului de sudare.