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IMPACT OF WELDING PARAMETERS ON THE STABILITY OF GAS METAL ARC WELDING PROCESS

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ABSTRACT
The stability of the welding process has a significant impact on the assurance of the required level of quality of welded joints. The increasing stability of the welding process reduces the probability of forming imperfections in the weld metal. The statistical analysis of the data obtained by monitoring the welding parameters in real-time was performed.This paper presents the results of the analysis of the impact of the parameters on the stability of gas metal arc welding process when the metal-cored electrode wire is used.
Keywords: gas metal arc welding process, metal-cored wire, welding parameters, electric arc stability, monitoring of welding parameters in real-time, statistical analysis of welding parameters

1. INTRODUCTION
Gas metal arc welding process has become very popular over the last two decades due to its simplicity and quality of welded joints that can be achieved by using it. At the beginning, welding was performed in a shielding atmosphere of pure gases, argon or carbon dioxide. In the recent years, the mixture of gases have been used instead. For welding of steel parts, depending on the steel grade, as a protective atmosphere in most cases, different mixtures of carbon-dioxide and argon are used with the addition of oxygen. Components of the mixture, their percentage share in the mixture and welding parameters affect the stability of the welding process and the mechanical properties of weld metal [1, 2, 3]. In order to increase productivity, metal-cored wires are often used besides the welding wires with solid cross-section. Regardless of the welding procedure that is used, there is always striving to provide the stable welding process. The increasing stability of the welding process reduces the probability of forming imperfections in the weld metal and affects level of quality. The aim of this study was to determine the influence of electrode wire feed speed and shielding gas mixtures on the stability of the gas metal arc welding process when the metal-cored electrode wire is used.

2. THE STABILITY OF THE WELDING PROCESS

The stability of the welding process is a characteristic of the electric arc. Variations in length of the electric arc cause changes to arc voltage and welding current intensity. During the welding process, fluctuations in these parameters are inevitable and happen very quickly, from several hundreds to several thousands times per second. These variations represent the dynamic characteristics of the electric arc, and take place as a result of the following effects combination: ways of guiding the electric arc; melting of filler metal and the types of the filler material transfer through the electric arc; possible changes in the thermal and electrical conductivity of filler material, base metal and the electric arc; and changes in the flow and the possible disruption of the shielding gas mixture flow. Stable welding process is characterized by a steady transfer of filler material through electric arc, relatively constant electric arc length and absence of scattering of the additional material. On the contrary, an unstable welding process is characterized by variations of the welding current intensity and electric arc voltage, and unbalanced transmission of the additional material through the electric arc. As a result scatterings will occur. The droplets of additional material solidify on the surface of the base material and on the surface of already solidified weld metal, which visualy confirmes instability of the welding process. In such cases it is necessary to correct welding parameters. The simplest method for determination of welding process stability relies on the analysis of signals obtained by using system for monitoring the welding parameters in real-time. These systems are based on measuring physical quantities in real-time during the welding process. Welding current intensity and electric arc voltage are most commonly measured. The results of the statistical analysis of these signals can be interpreted in terms of quantification of welding process stability.

3. EXPERIMENTAL PROCEDURE

The plates of microalloyed steel of grade P461NL1, 14 mm thick, were used as a base material for welding. The chemical composition of the base material is: Fe balance – 0,153 % C – 0,38 % Si – 1,40 % Mn – 0,015 % P – 0,0021 % S – 0,031 % Al – 0,037 % Cr – 0,63 % Ni – 0,004 % Mo – 0,061 % Cu – 0,099 % V – 0,038 % Nb – 0,004 % Ti – 0,0003 % B – 0,0052 % N. Welding was performed by using commercially available metal-cored electrode wire Filtub 12 M of the Slovenian producer "Jesenice", with a diameter of Ø 1,2 mm. Filtub 12 M is an low-alloyed metal-cored electrode wire, suitable for welding low-alloyed steels and fine-grained steels. This wire is characterized by a smooth surface of the weld metal and high mechanical properties of the weld metal at low temperatures. The chemical composition of the filler material is: Fe balance – 0,05 % C – 0,55 % Si – 1,40 % Mn. The manufacturer recommends using this filler material with shielding gas mixture from the M21 group (Ar + 15 % < $CO_2 \leq$ 25 %), as defined by international standard ISO 14175:2008 [3, 4]. Electrode wire was used in combination with two shielding gas mixtures: 82 % Ar + 18 % CO_2 (M21, according to ISO 14175:2008) and 93 % Ar + 6 % CO_2 + 1 % O_2 (M24, according to ISO 14175:2008) [4]. For each combination of electrode wire and shielding gas, welding was carried out with two different wire feed speed of 3 m/min and 7,5 m/min. Preheat temperature of the base material was 150 °C. A total of four samples were welded. The combination of welding parameters for each sample are shown in table 1. Devices from Finnish producer of the welding equipment "Kemppi" were used for welding and monitoring parameters of the welding process in real-time. The following devices were used: power source - Fast MIG Pulse 350, wire feed unit - Fast MIG MXF 65, MAG/MIG welding gun, device for monitoring welding process parameters in real-time - Fast DLI 20 and computer with installed acquisition software package Pro Weld Data. In order to analyse the stability of gas metal arc welding process, when metal-cored electrode wire was used, the intensity of the welding current was measured in real-time for the period of one hundred seconds during the welding of each from the four samples.

Table 1. Welding parameters

Samples	1	2	3	4
Shielding gas	M21	M21	M24	M24
Electrode wire feed speed (m/min)	3	7,5	3	7,5

4. RESULTS

Based on the measurements conducted during welding of each sample, signals that represent changes of the welding current intensity in the time domain were obtained. For better understanding of the results, methods of descriptive statistics were applied for the analysis of obtained signals. For each of the four signals obtained by measurments conducted in real-time during welding, the distribution of the welding current intensity was formed, figure 2. The results of statistical processing of the data are shown in table 1.

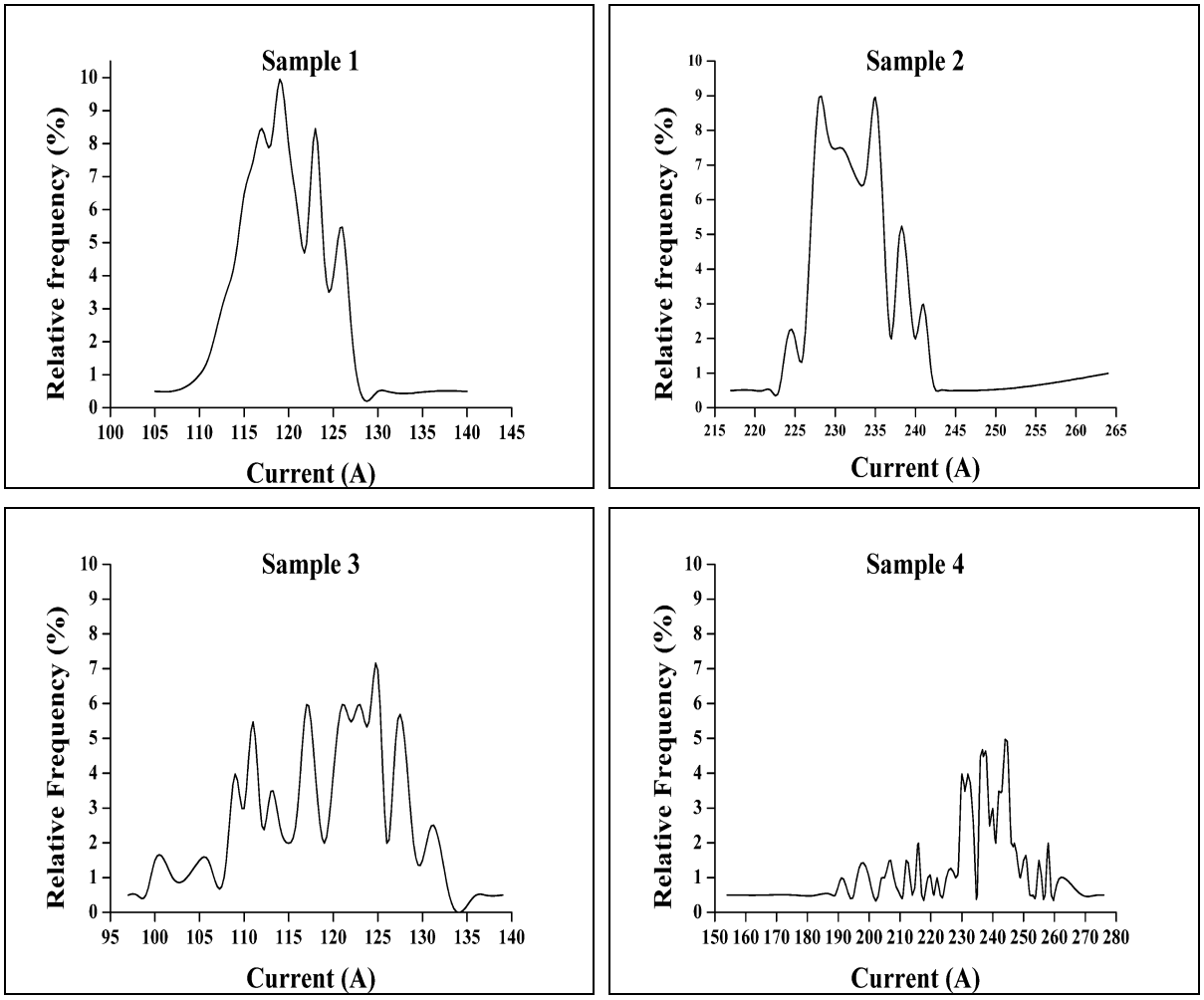

Figure 2. Distributions of welding current intensity

Table 2. The results of statistical processing of the data

Sample	Welding current				
	Mean	Mode	Median	Standard deviation	Coefficient of variation
	(A)	(A)	(A)	(A)	(%)
1	119,463	119	119	4,759	4,984
2	232,697	228	232	5,829	2,505
3	118,970	125	120	7,967	6,696
4	232,682	244	237	19,166	8,237

5. CONCLUSIONS

Based on the shown results it can be concluded that the stability of the gas metal arc welding process depends on the welding parameters, such as protective atmosphere and the electrode wire feed speed. Based on the mutal comparison of the coefficients of variation of welding current intensity it is possible to compare the welding process stability in cases when different process parametars are used. Based on the results shown in figure 2 and values of coefficients of variation shown in table 1, it can be noted that the use of recommended protective atmosphere M21 has a positive impact on the variability of welding currrent (lower coefficients of variations; coefficient of variation decreases when the wire feed speed increases), compared to the shielding gas M24 (higher coefficients of variations; coefficient of variation increases when the wire feed speed increases). Shielding gas M24 is not suitable for use with this particular metal-cored electrode wire, because it negatively affects the stability of the electric arc. The reason for a reduction in the stability of the welding process could be found in the chemical composition of flux stored in the core of the electrode wire which producer of filler material does not list in catalogue. This confirms the manufacturer's recommendations that an adequate shielding gas mixture should be used with the specific type of the filler material.

6. REFERENCES

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