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Arc Weld Multi-Station System for Controlling Welding Parameters

Abstract: The progression of automation and strong market competition dictate a rise in productivity without compromising, and sometimes even with increasing quality-related requirements. As a result, in big industrial companies, the control of production processes based on traditional inspection methods is significantly limited, expensive and impossible to perform on a continuous basis. Consequently, quality control related to welded joints is randomised and based on destructive testing. Although such welded joint quality control enables obtaining very good results in terms of joint quality control, its cost, time and possibility of assessing only a selected set of specimens make the method impossible for performing complex assessments of ongoing production processes. This has led to the rising popularity of methods supporting the evaluation of joint quality control enabling the non-invasive assessment of each joint. To this end it has become necessary to apply systems making it possible to continuously control electric parameters characterising welding processes. For many years, Instytut Spawalnictwa has been carrying out tests and developing measurement equipment for monitoring welding processes. Such equipment and systems find applications in industrial companies, both for welding process control and assessment as well as for adjusting welding process parameters. One of such systems is an Arc Weld multi-station system for monitoring process parameters.

Keywords: ArcWeld, monitoring systems, welding parameters, joint quality

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Introduction

Each production facility aims to manufacture products of the highest possible quality in order to succeed in a very competitive market. Product features satisfying increasingly demanding customers include not only quality but also reliability, fatigue life, functionality and appearance. In addition, product quality directly affects the brand image of the producer. The importance of quality is growing in all areas of economy and is strictly related to competitiveness, which usually imposes a growth in demands for technologies and manufacturing processes. In metal joining processes, workmanship is also a factor affecting product competitiveness. Electric arc welding is one of the methods most commonly used for joining metals, finding application in almost every industrial area where it is used for making joints having quality as the key importance.

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The progress in automation and strong market competition dictate a rise in productivity without compromising, and sometimes even with increasing quality-related requirements. As a result, in big industrial companies, the control of production processes based on traditional inspection methods is significantly limited, expensive and impossible to perform on a continuous basis. Consequently, quality control related to welded joints is randomised and based on destructive testing. Although such welded joint quality control enables obtaining very good results in terms of joint quality control, its cost, time and possibility of assessing only a selected set of specimens make the method impossible for performing complex assessments of ongoing production processes. Such tests provide only fragmentary information about ongoing processes and usually do not enable the determination of factors which disrupt processes on a random basis.

This has led to a rise in popularity of methods supporting the evaluation of joint quality control enabling the non-invasive assessment of each joint. To this end, it has become necessary to apply systems making it possible to continuously control electric parameters characterising welding processes, i.e. welding current and arc voltage waveforms as well as filler metal feeding rates and shielding gas flowrates.

System Description

For many years, Instytut Spawalnictwa has been carrying out tests and developing measurement equipment for monitoring welding processes. Such equipment and systems find applications in industrial companies, for both welding process control and assessment as well as for adjusting welding process parameters. One of such systems is the Arc Weld multi-station system for monitoring process parameters, the architecture of which is presented in Figure 1.

The multi-station system for welding process control is a state-of-the-art system for data acquisition. The system has a two-layer client–server type architecture and is composed of measurement modules for archiving and sending process-related information to the server. The server software analyses and assesses the process and archives obtained information in a database. The system is also provided with a user application being an interface between personnel managing production processes and process-related information stored in the database. The exchange of information between these system elements is done via a computer network (Ethernet, Wi-Fi).

The measurement modules constitute part of the scattered measurement system and are installed on each welding power source supervised by the welding process monitoring system. The modules automatically detect the start of the welding process, record key waveforms in relation to weld quality, i.e. the waveforms of welding current and of welding arc voltage. The modules may also contain a measurement track of filler metal feeding rate or of welding rate and of shielding gas flowrate).

The server is tasked with archiving and assessing welding processes on the basis of the data obtained. Waveforms enable determination of derivative quantities, which are next used for defining quality indicators for each joint made. The quality assessment algorithm is based on methods of statistical process control.

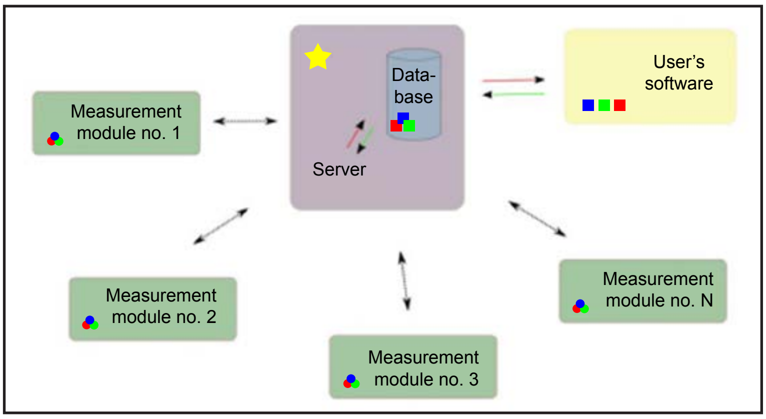

Fig. 1. Architecture of Arc Weld multi-station welding process control system

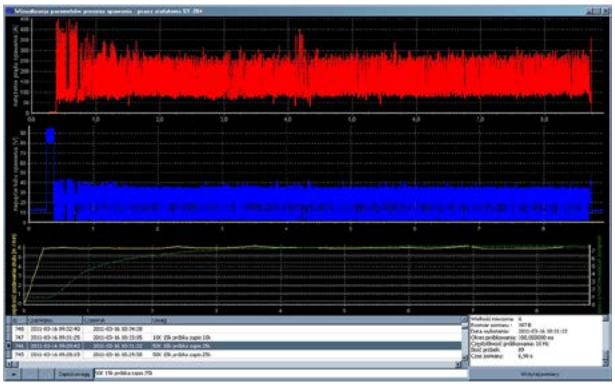

Fig. 2. User interface – exemplary arc welding process waveforms

The production process managing personnel are provided with an application for visualising ongoing welding processes. Figure 2 presents the graphic interface of the application.

The upper diagram of the application window presents the waveform of welding current (red colour). The diagram in the middle (blue) presents the waveform of electric arc voltage during welding. The diagram at the bottom presents the waveforms of shielding gas flowrate (green) and filler metal feeding rate (yellow).

Analysis of Process Variability

The basis for the statistical analysis of the process is the determination and, at the same time, differentiation of the reasons responsible for the process variability. In practice, it is possible to enumerate two groups of factors causing process variability, i.e. a group of random factors responsible for slight process variability, also referred to as natural process variability, and a group of special factors responsible for significant process variability resulting in the deterioration of process-related properties.

The first group tends to include factors related to the variability of environment conditions, i.e. changes of pressure, temperature, humidity, vibration, equipment variability, changes of welder psychophysical state and the variability of process monitoring equipment. If only such factors are present, the process is regarded as statistically stable or *in-control*.

The second group of factors includes special factors, the presence of which is usually easily noticeable in the form of significant fluctuations of process parameters and quality-related problems. In such situations, the process is referred to as unstable or *out-of-control*. [5-6].

These factors include unstable welding process parameters (deviations from the nominal value of welding current, welding arc voltage, welding time and filler metal feeding rate), unstable operation of equipment and of mechanical systems, improperly prepared workpieces, changes of workpiece material parameters, contact tube wear, problems with matching etc.

Improperly selected technology, unsatisfactory qualifications of technical personnel, bad organisation of work and production processes as well as frequent adjustment or unjustified changes of welding parameters contribute to the generation of variability and fluctuations in welding processes. These fluctuations are manifested by joint quality problems and reflected in the observed waveforms.

Figure 3 presents examples of welding current and welding arc voltage waveforms for a stable process (A) and for a disrupted process (B, C).

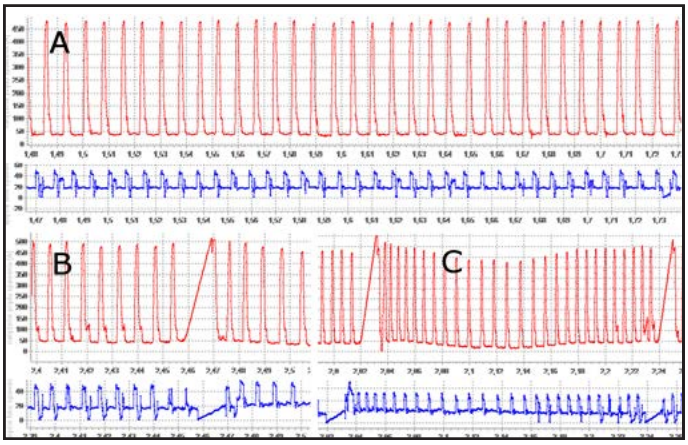

Fig. 3. Welding current waveforms (red) and welding arc voltage waveforms (blue), A – undisturbed process, B and C – interferences (waveforms come from a robotic station)

Due to laboriousness, it is not possible to perform the analysis of recorded waveforms systematically during a production process. Due to this fact, it is necessary to calculate numerical indicators characterising each successive joint. As regards welding current, a good indicator describing the variability of this parameter during welding is the root-mean-square current.

The indicator value is determined for each joint made, and next, entered in control sheets. As a result, the production process analysis is simpler and less time consuming.

Figures 4-7 present examples of welding current control sheets for processes of various characters, i.e. stable, unstable (out-of-control), with continuous and random interference.

Arc Weld System Advantages

The implementation of the presented system in a production company is connected with many advantages:

- continuous monitoring of production processes (and of each joint made),
- automation of the quality assessment process in relation to joints,
- archiving of welding process parameters,
- elimination of defective elements from further production,
- optimisation of production processes,
- improved quality of joints,
- increased process reliability and customer confidence,
- decreased number of complaints,
- reduced costs of quality control and of production,
- relatively easy adaptation of the system within a production facility,

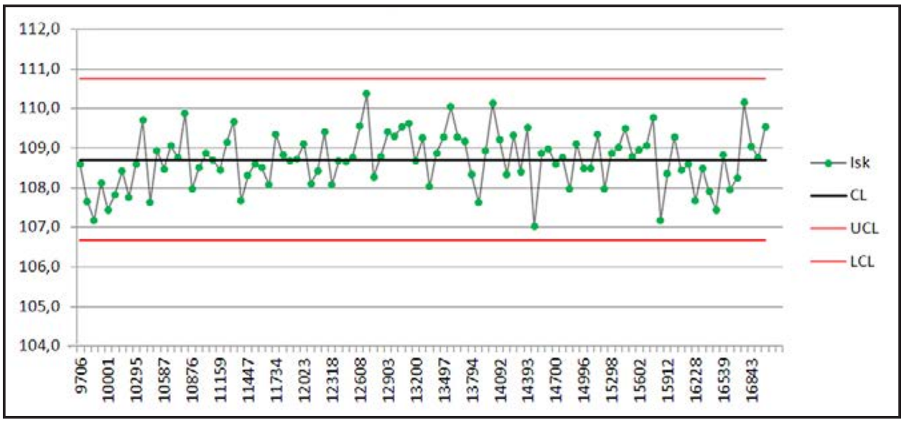

Fig. 4. Control sheet for root-mean-square current value – stable process (lack of maladjustment)

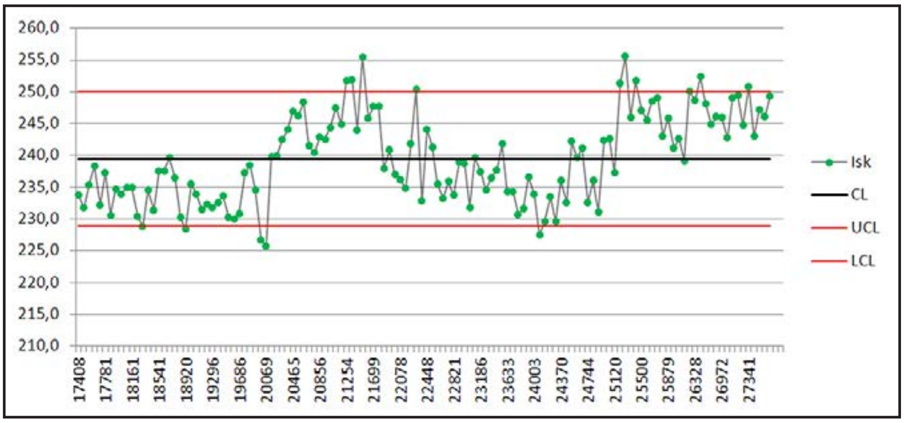

Fig. 5. Control sheet for root-mean-square current value – unstable (out-of-control) process (sinusoidal interference)

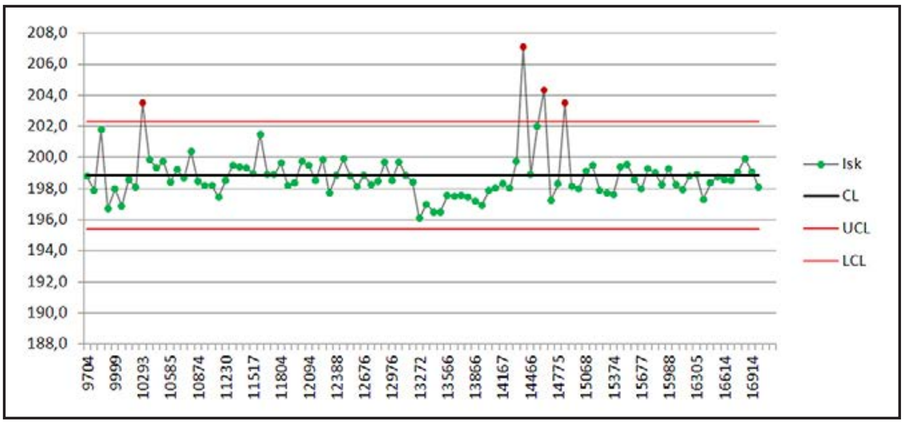

Fig. 6. Control sheet for root-mean-square current value – stable process (single interferences)

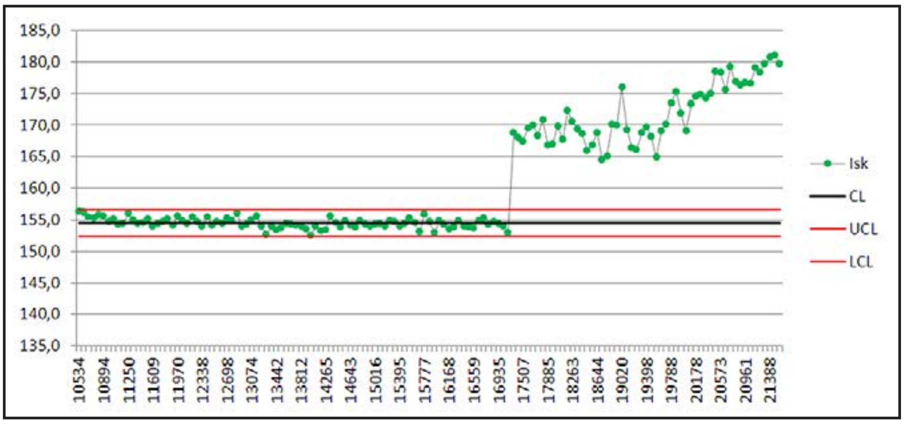

Fig. 7. Control sheet for root-mean-square current value – process stable until the introduction of continuous interference

– module-based structure (easy extension of both hardware and software), high scalability.

Summary

The use of the multi-station system for monitoring welding parameters enables the complex and continuous assessment of welding processes at a relatively low cost. Such a solution makes it possible to significantly limit the number of non-destructive tests and automate the process of quality assessment, which is of great importance for increasing productivity. Also, the possibility of assessing quality on a real-time basis enables instant interventions if quality-related problems occur.

As industry develops, equipment and measurement systems for welding process control undergo significant development as well. Similar progress can be observed in the offer of Instytut Spawalnictwa related to equipment for measuring and controlling welding processes.

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