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Collection of arc welding process data

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ABSTRACT

Purpose: The aim of the research was to examine the possibility of detecting welding imperfections by recording the instant values of welding parameters. The microprocessor controlled system for real-time collection and display of welding parameters was designed, implemented and tested.
Design/methodology/approach: The system records up to 4 digital or analog signals collected from welding process and displays their run on the LCD display. To disturb the welding process artificial disturbances were introduced.
Findings: The occurrence of some welding imperfections is followed by changes of the welding parameters. In this case they can be revealed by the analysis of the instant values of the welding parameters.
Research limitations/implications: In the paper results of monitoring manual metal arc welding and gas metal arc welding are presented.
Practical implications: Monitoring of gas metal arc welding is a good tool for evaluation of the quality of weld. All introduced, artificial disturbances of the welding process destabilize the welding arc and produce changes in the instant values of the welding parameters.
Originality/value: The paper presents a modern microprocessor controlled system for real-time collection and display of welding parameters. Results of tests show that simple statistical approach to welding parameters can help in evaluation of weld quality.
Keywords: Quality assessment; Welding; MAG; Monitoring

1. Introduction

Welding process emits sound, light and electromagnetic radiation to surrounded space. Sound emission and light emission were exploit as a source of information about the process [1,2,3,4] but till now welding parameters are counted as a main source of data for welding process monitoring which can be essential part of online evaluation of weld quality [5,6]. Parameters of welding are controlled by electronic control units [7,8] but their modulation by welding process can be exploited for monitoring of welding process. The design of the monitoring system should predict the high electromagnetic interferences during the welding process on the microprocessor-controlled system [9]. Disturbances of welding process affect usually the stability of welding arc [10,11]. Some of them produce momentary instability of welding arc and other make the arc unstable as long as the disturbance affects the welding arc.

Speed of analogue-digital conversion is a compromise between quantity and quality of recorded data. A great many of recorded data enlarge time of computation but limited number of data can be a reason of missing essential information. Previous work in monitoring of arc welding processes were emphasized on finding the best way for analyzing recorded signals and application the statistical quality control in monitoring of welding process [12,13]. The aim was to distinguish sound weld and areas of weld were imperfection are expected. It is possible to find faulty area of weld and find the reason of process disturbance by using statistical method or computational intelligence [14,15].

Condition of data recording have been neglected in those research because laboratory recorders can work in wide range of parameters. Presented in this paper monitoring device intended for industry use has fixed recording parameters and input circuit dedicated for welding processes.

2. Description of the measuring system

2.1. Spread architecture of the system design

The architecture of the measuring device, Fig. 1, is based on the modern "spread" architecture – there are four 8-bit slave-controllers that perform the local tasks. The main processor measures and converts input data, its storage in memory and reads it during the external transmission and supervises the supply with a backup. The external transmission is controlled by a specialized processor. Basic parameters of each welding process are computed locally. The device can measure AC (true RMS) and DC voltage (0 - 60 V) and AC or DC current (0 - 1000 A). The design of the device is prepared for low-level technology manufacturing (the device preferably contains PLCC and DIP devices and only a few SMD devices). The future development of the device is possible owing to the PLD-based "chipset" with in-circuit programming, the "open" architecture with external digital and analog buses and the "oversized" interrupt controller.

2.2. External digital transmission and analog buses of the system

The system has an external digital bus that is used for connecting controllers of amplification ratios for the analog inputs. It has 3 serial ports – one for external data transmission, the second for testing and maintenance of the device, the third port, with all the modem lines included, is prepared for (not used yet) transmission options IrDA or USB converter. There is a standard parallel port for printer because the report with welding parameters is required to confirm the high quality of the produced welds. The analog bus with the normalized input range 0-2.5 V is designed for 8 analog inputs converted with 12-bit resolution, however, only current meter, voltage and gas flow sensors have analog outputs; the wire speed is measured by the encoder that gives 3 series of pulses counted in the motion controller. Two inputs measure the voltage of the memory battery and the main supply battery.

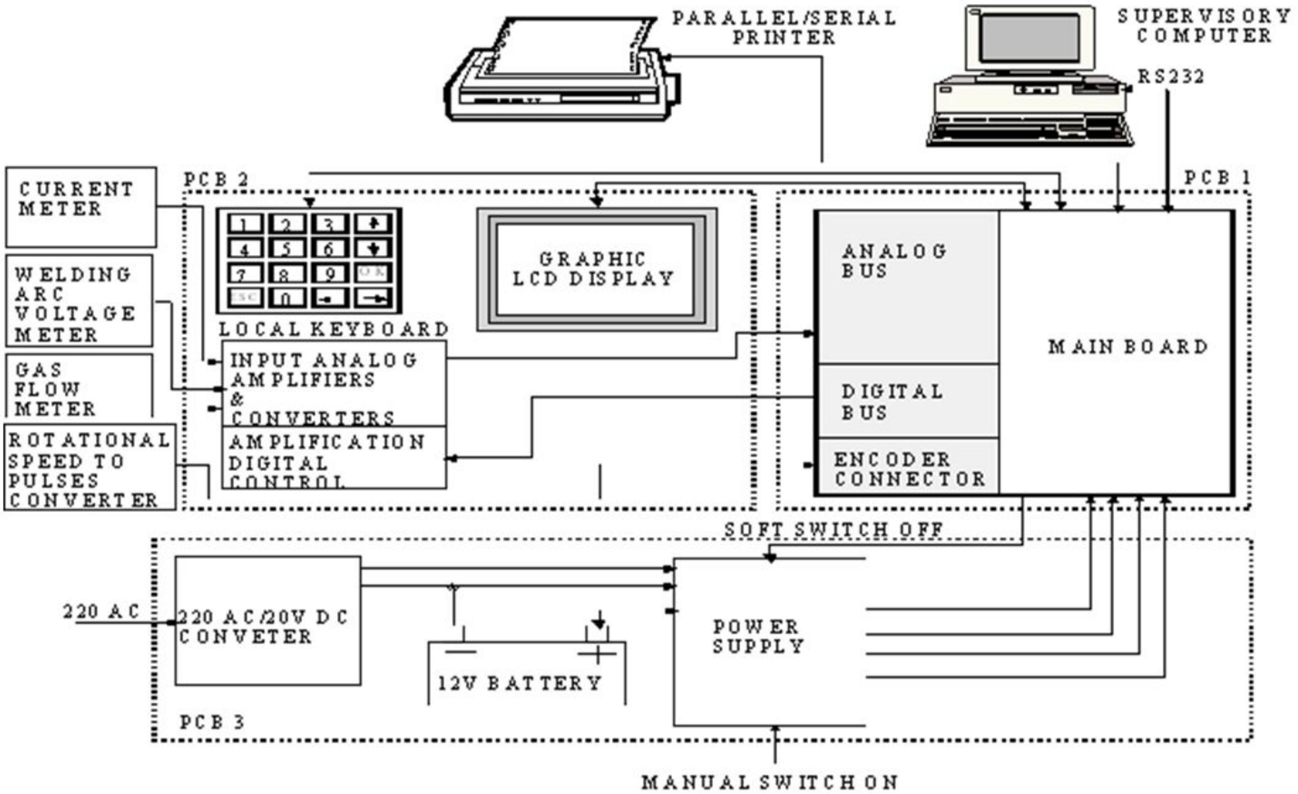

Fig. 1. The block diagram of the measuring system

2.3. Data memory structure

The sufficient frequency of measurements is 128 measurements of each parameter per second, every consecutive 8 measurements are summed and averaged and the mean value is stored in the memory (16 mean values per second).

With 4MB SRAM, 12-bit data converters, predicting 2 bytes space for the each stored data, and with 4 input data channels, the system is able to measure, collect and store data through out the whole work day – about 32000 s. The memory organization allows storage of records of various length. The allocation table in the memory describes the structure of the memory.

2.4. Local data visualization

The measurements are presented on the graphic LCD display – the average values for each 0.25 second are displayed. The typical time 60 s of welding one pass can be visualized on one screen. All the stored records can be independently looked up, and the basic data of the particular welding process can be printed locally in the measuring system as a report. After measurements the device can transmit the stored data to a PC where the supervisory program analyses the whole process and estimates in detail the welding parameter runs. The measured duration time of the welding process, and the real time of the welding beginning is given in this report. Data collecting can be started by pressing a key on the keyboard or automatically in the case when the welding current exceeds the 50 A level.

2.5. Power supply

The system works with an external battery supply and the memory has an additional backup supply from a small battery located on the main board. The system cannot be switched off if the data storage is not completed. If the system would be reset during data collection, the data set would not be damaged. In this case the user can use the option of the automatic recalculation of data. The main processor holds a "soft" switch on till the end of the current action.

2.6. EMC of the system

Measuring currents up to 1000 A and voltages to 60 V, requires special care for the system EMC [9] and requires the implementation of some extra data and address buffers designed into the PLD technology. An isolation amplifier (in the voltage measuring channel) and amplifiers with high input over-voltage protection are used as well the most serious problem with noises appears when measuring parameters of the TIG welding, in which the air gap between the electrode and welded material is ionized with almost 10 kV pulses before firing the arc. The graphics display with its own controller can easily be disturbed, and in some cases it can block the action of the whole system. The problem is to design a high efficiency low-pass filter dumping and cutting the spikes on the isolated voltage input, and EMI filters on the other inputs. However, in the other methods of welding, the described system measures parameters perfectly.

3. Experiments

The aim of the research was to examine the possibility of detecting welding imperfections by recording the instant values of welding parameters. Disturbances were implemented in three areas 25 mm in length. These areas were separated by clean areas 50 mm in length. The beginning and the end of weld were also free of disturbances.

Welds on plates were produced manually. Two types of covered electrode: rutile-acid electrode and basic electrodes of diameters 3.15 and 4.0 mm were used for MMA welding.

For MAG welding the wire SG3S1 of diameter 1,2 mm and gas mixture M21 were used.

Beads on plate were executed on S235 steel sample tests. Sample tests were 250 mm long, 100 mm wide and 6-8 mm thick.

The research covered the area of MMA welding in the range of current from 130 A to 180 and MAG welding in the range of current from 160 A to 310 A. Three levels of welding current were used to cover the recommended range of parameters for the consumables that were used.

To disturb the MMA welding process three types of disturbances were introduced: a layer of paint, a layer of grease and a layer of oil. A lack of shielding gas was introduced as the forth disturbance during MAG welding.

Welding current and welding voltage were recorded during MMA welding and welding current, welding voltage, wire speed and gas flow were recorded during MAG welding.

4. Results and discussion

All test coupons were visually and radiographically examined. In the areas where disturbances were implemented macroscopic examination of the weld cross section were performed. Results of these examination were compared with the runs of welding parameters.

There are three types of welding process disturbances. The first influences the stability of welding arc, the second influences welding parameters and the third influences the metallurgical reaction in the arc and welding pool. It seems that three applied disturbances affect weld metal in the same way, all of them are able to produce gas pores. It is necessary to note that welding arc deliquesces grease and oil and blow them out from the welding area. Only a part of fumes and vapors is absorbed by the arc column. A layer of paint burns in the welding arc and most of products of its disintegration are absorbed by arc.

Monitoring devices can only reveal disturbances and imperfections that influence the welding parameters, mainly welding voltage and welding current. Both of these parameters depend on potential of ionization, which depends on the chemical composition of welding arc stream. Changes in the potential of ionization influence the temperature of the welding arc, voltage drops in the arc stream, cathode and anode region and arc current density.

Visual examination and X-ray examination of MMA welds shows that this method of welding is to a minor degree sensitive to applied disturbance. Only a layer of paint develops minor gas pores and changes of parameters in this area are not clearly visible. A layer of grease and a layer of oil did not cause visible changes in the radiograms and plots of runs of parameters.

Minor indications in the plots were caused by the silica borders of contaminated area.

During MIG welding shielding gas, silicon and manganese compounds protect the arc and welding pool from oxygen and nitrogen. There is no possibility to neutralize chemical compounds which penetrate the arc. All disturbances influence metallurgical processes in the welding arc and the weld pool also influence the stability of welding arc. In all cases disturbances produce imperfections at the surface of the weld and also produce internal gas pores. It is seen that the intensity of welding parameters change is directly proportional to intensity of disturbance. This also happened when the gas shield of the arc was penetrated by oxygen and nitrogen from the air, Fig. 2.

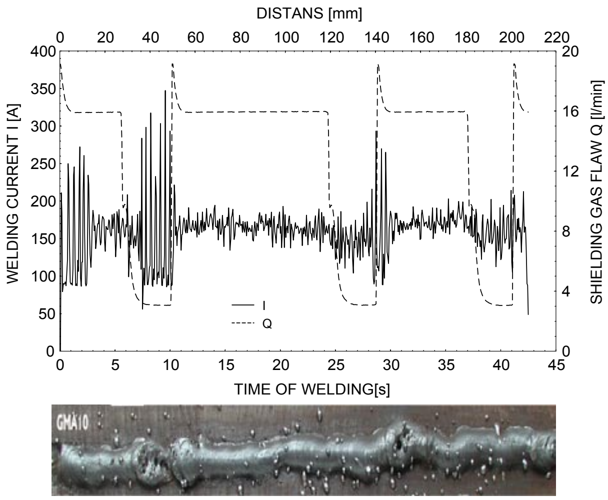

Fig. 2. Instant value of welding current and welding voltage during GMA welding. Lack of gas shield as a disturbance of the welding process is seen in the plots and the weld

5. Conclusions

The measuring system for arc welding processes, has a modern, easy to expand structure. It measures and records the most important welding parameters. It enables online evaluation of welding data and a detailed post-weld analysis of data on a PC. Tests of the device performed during manual metal arc welding and gas metal active welding revealed that the occurrence of some welding imperfections is followed by changes of the welding parameters. In this case they can be revealed by the analysis of the instant values of the welding parameters. Experiments show that monitoring gas metal arc welding is a good tool for evaluation of the quality of weld. All introduced, artificial disturbances of the welding process destabilize the welding arc burning and produce changes in the instant values of the welding parameters. In the case of manual metal arc welding changes of instant values of the welding parameters are barely noticeable and can be missed during online study.

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