Optimization of welding of wire crossings using energetic method

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Keywords

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1. Introduction

It was elaborated a test method to evaluate the strength of welded joints in case of complex load, which is suita-ble for evaluation of specimen and pieces of fully manufactured goods. On the basis of complex evaluation of mechanical and electric tests parameter intervals were obtained which enable the determination the primary parameters of spot welding. It is necessary to emphasize that the primary parameters significantly depend on the state of welder, the contact resistance of electric connections, moreover the distance between consoles of electrodes on the top and at the bottom (so-called window effect).

The basic technology of welding of wire crossings as the button welding is a special version of the spot welding. As initial conditions the connections between parameters of spot welding were accepted and differences were looked for during the evaluation of specific features.

There is no added metal needed to electric spot welding. As energy source the Joule effect of electricity is used. During the welding the components are pressed to each other and simultaneously electricity is switched on. After the current passage the clamping force is retained in adjusted manner. In this way a prescribed time-delay is applied compared to time interval of energy input.

In welders the electricity goes through the transition resistance between electrodes enabled the needed Joule effect to smelt of welding point.

The key of our investigation the determination of demand for energy of welding was considered. On the basis of our consistent experiments the optimal intervals of welding parameters were determined and prescribed for each welder as a part of technological documentations [1], [2].

2. The aims of the investigation

The following requirements related to the investigation were determined:

- Elaboration of procedures for evaluation and qualification of technological parameters to the applied resis-tance welding;
- Elaboration of methods for investigation;
- To perform parameter tests and qualifications of products and manufacturing equipments;
- Processing of acquisited data;
- Evaluation of results;
- On the basis of evaluated results determination of optimized intervals of welding parameters.

3. Methods of investigation

On the basis of above mentioned aims methods for evaluation and measuring of technological parameters of resistance welding were elaborated. To the investigation the procedures of measuring and mechanical tests were carried out.

3.1. The investigation of welder and determination of the characteristic curve of it

The electric and mechanical basic parameters of welding technology ensuring eligible quality are the followings:

- Amperage and ampere density of welding;
- Forces acting on electrodes and its change in function of time;
- The influence of fastener forces on transient resistance;
- Duration of energy transport.

Technological parameters during the welding process are determined by technical data, range of set values and quality level of equipment.

Operating manuals of welders do not contain the physical quantities of actual set values (amperage, fastener forces). For this reason as the first step it was needed to determine the characteristic curves of welding parame-ters.

As results of investigations the following answers were looked for:

- connection between pressures during welding and the magnitude of electrode forces;
- connection between output voltage of transformer welder set on the primer side and amperage.

The needed instrumentation of each process was determined on the basis of these aims.

3.2. Instrumentation

On the basis of pneumatics features of the welder it was necessary to decide on recording of in function of time variable forces acting on electrodes during the whole cycle of welding. Taking into consideration of real possi-bilities an indirect manner of force measuring was chosen. The force of welding was resulted from pressure in a pneumatic power cylinder. The variable pressure inside was measured using three pressure detectors. The in function of time variable welding force was calculated on the basis of geometric data of pneumatic power cylinder.

In order to check the calculated forces a multipurpose instrument was applied to compare the forces calculated by measured pressure and measured directly by load cell. In this way the frictional losses were determined and the measuring method was calibrated. The block sketch of load measuring and its results can be seen in Figures 1 and 2 [3].

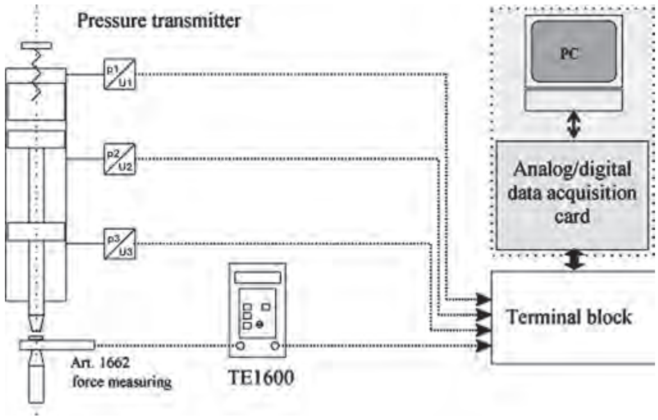

Figure 1. The measuring of welding load

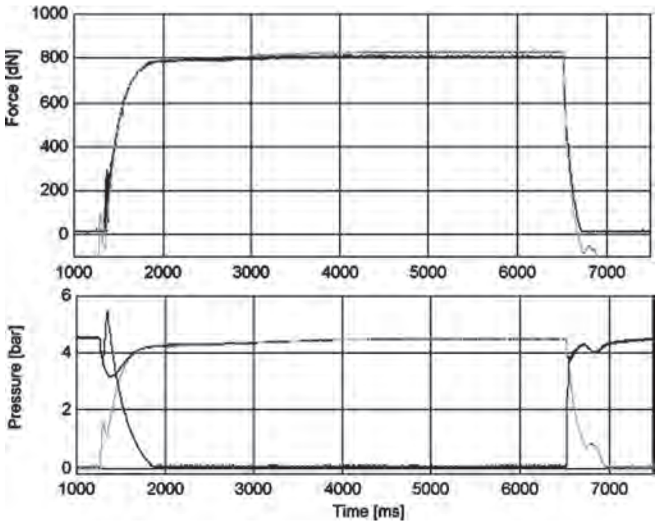

Figure 2. An example of contemporaneous application of load cell and pressure detectors

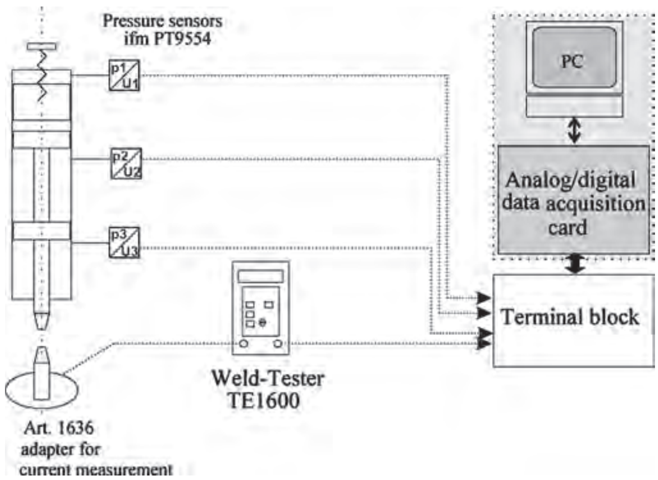

Figure 3. Measurement of welding electric current

For measurement of welding electric current was made by the aid of a special adapter of the instrument. The block sketch of the measurement can be seen in Figure 3 [3].

One of aims was the contemporaneous measurement of electrode loads and electric parameters. It was made by contemporaneous recording of measured data of pressure detectors and voltage. The measured and processed data were demonstrated by diagrams ensured the evaluation of the factual welding parameters.

3.3. The measuring of electric parameters of welding process

The applied basic equation (Joule-law) in the process of resistance welding describes the connection of physical quantities exerted influence on the quality of welding.

$$Q = \int_0^t RI^2 dt$$

where:

Q (J) - the generation of heat;
I (A) - amperage flowing through the weld;
t (s) - duration of flowing through of electricity;
R (Ω) - sum of resistances between electrodes.

Generated heat can be determined by this equation. The force between electrodes is not directly in the equation however it is an important factor in the process of energy transport. The initial ampere density of welding, tran-sient resistance between connecting surfaces of components, the energy distribution moreover electric losses are influenced by the magnitude of force between electrodes and its change in function of time [1], [2].

In spite of above mentioned parameters the magnitude of factual resistance can be determined by contemporaneous measurement of voltage. It was needed to measure the voltage between the electrodes, amperage flowing through the weld and the pressure in the hydraulic power cylinder at the same time.

The measuring plan was carried out according to these requirements.

3.4. Measurement of forces acting on electrodes without electricity

For determine the calibrated magnitude of force between the electrodes changing in function of time calibrated load cells were applied. The force generated by pneumatic power cylinder was adjustable by change of pressure in the pneumatic cylinder. The magnitudes of forces calculated by measured data of pressure detectors and measured value of load cell were compared to each other. In this way the frictional losses and state of the cylinder were determined.

On the basis of measured and processed data it was found out that the frictional loss of each cylinder is quite different for this reason the generated force between electrodes is different as well [4].

3.5. Determination of forces during the welding process

The variable force between electrodes was calculated by using pressure detectors. The variable pressure in the pneumatic cylinder and electrical parameters were measured and recorded at the same time.

The dynamics of pneumatic and electric processes are significantly different. The amperage flowing through the weld starts at the beginning of increasing of pressure in the cylinder. The force between electrodes reaches its highest level in the second phase of the welding process which is advantageous from point of view of quality of granular structure of weld.

If the amperage flowing through the weld starts too earlier compared to increasing of pressure the small force between the electrodes is not able to keep the melt between wires to be welded to each other.

From these facts it emerges that the timing of changeable pressure and electric processes has fundamental importance from the point of view of quality of weld.

4. Weld test of specimen and segment of final product

The effect of set values of welders on quality of welds was assessed by two methods.

- mechanical tests of specimens made by welding of wire crossings;
- mechanical tests of cut out segments of different final products.

4.1. Strength test of specimen

Crossed specimens were applied to strength test acting on them deflecting forces. To the test a special rig was developed applying it in tensile-strength tester (Figure 4).

Figure 4. Specimen in tensile-strength tester

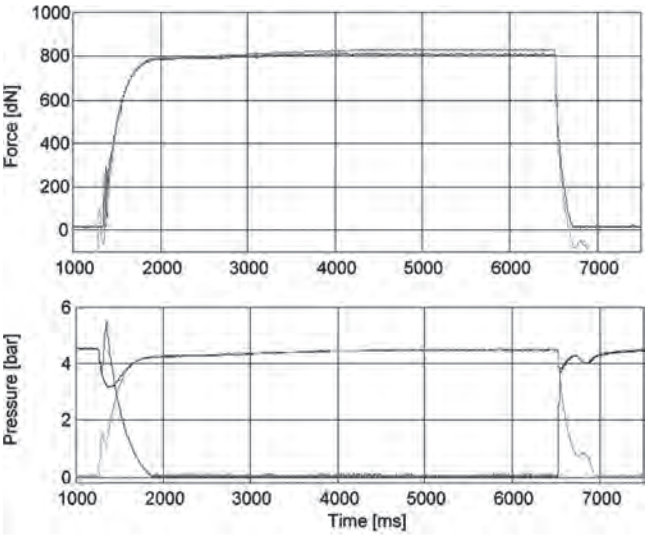

Figure 5. Results of investigation of one of welders

4.1.1. Completed measurements

Determination of force between electrodes was calculated by using pressure detectors and checking using load cells. The results of investigation concerning one of welders can be seen in Figure 5.

4.1.2. Measurement of welding amperage using measuring loop

The measurements were made by combined instrument (static state) and virtual instruments enabled digital data processing (dynamical state). The applied time step was 0.5 ms.

4.1.3. Measurement of voltage between electrodes by virtual instrument

To the energetic assessment of welding it was needed to measure the in function of time variable voltage be-tween electrodes. An example can be seen in Figure 6.

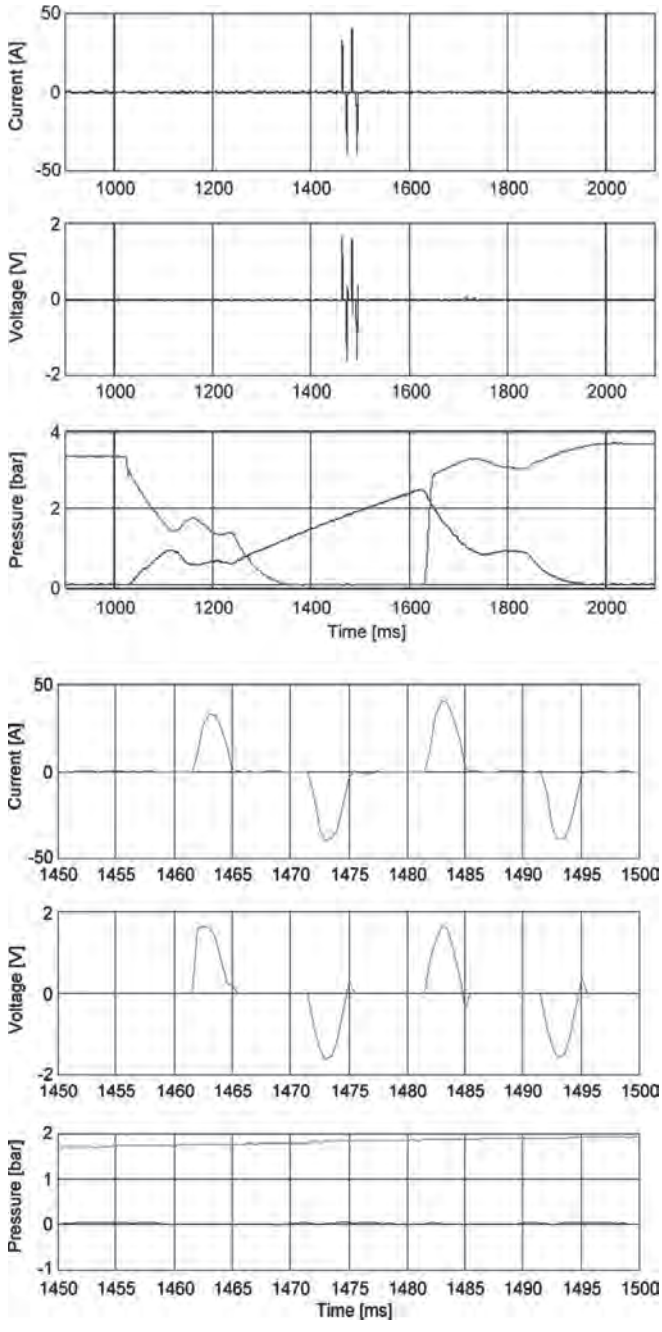

Figure 6. An example of measured data

The measured data for each welding were stored almost in 1000 rows. In each row the time, the amperage, the pressure and voltage were recorded.

4.1.4. The characteristic of welder

It was needed to recognize that the welders located in different places in the plant in spite of the same set values worked in different manner especially concerning the pressure in the pneumatic power cylinder and voltage between electrodes. This phenomenon shows the different state of power cylinders. Differences of electric para-meters were explained by different losses of local electric network.

Because of mentioned differences of parameters and for the sake of correct assessment it was necessary to record the force between electrodes and amperage diagrams in order to optimize the energy transport during the welding process.

Due to the different state of welders used in the plant different set values had to be determined for each machine.

4.1.5. Deformation of specimens caused by welding

In second phase the height of welded wires (almost double diameter) was measured in order to determine the difference between before and after welding. On the basis of experiences significant correlation can be found between decreases of height of wires and energy transport.

This correlation is suitable for qualifying the finished welded joints.

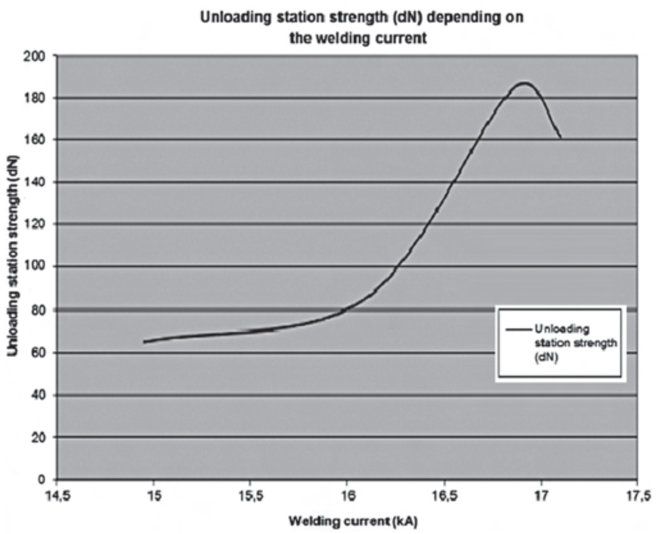

Figure 7. Breaking strength in function of welding current

4.1.6. Results of strength test of specimen

In third phase of the investigation strength tests of welded specimens were made. In Figure 7 the results of strength tests can be studied.

4.2. Mechanical tests of cut out segments of different final products

After the tests of specimens the electric parameters were measured and forces between electrodes were calcu-lated on some cut out segments of final products.

4.2.1. The shape of cut out segment of final product

To strength tests some segments were cut out from welded lattice-work. After welding the height of welded joints were measured in order to determine the compression of wires. The final product during the resistance welding in Figure 8 can be studied. The cut out segment of it in Figure 9 moreover some specimens made from final product in Figure 10 can be seen.

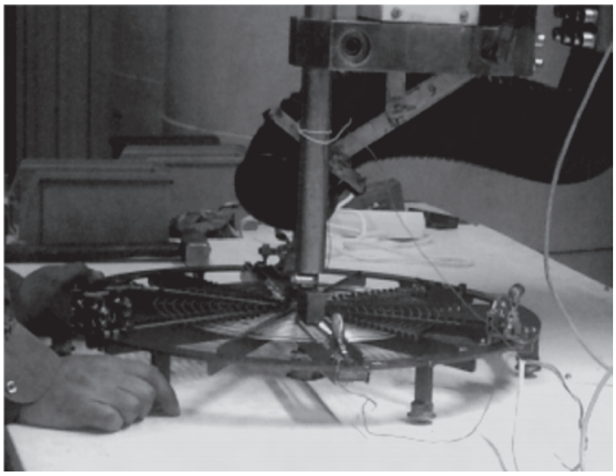

Figure 8. Final product during welding

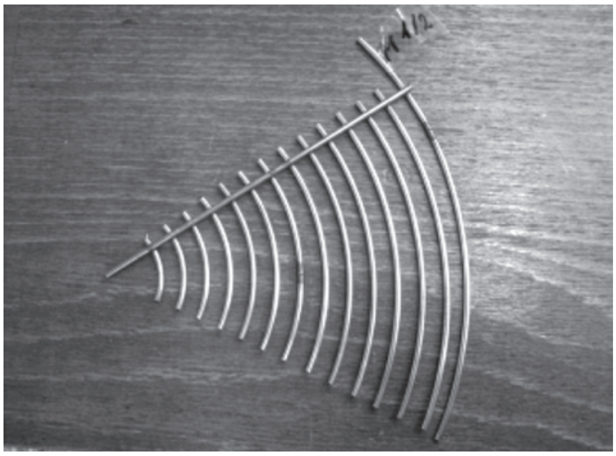

Figure 9. Segment of final product

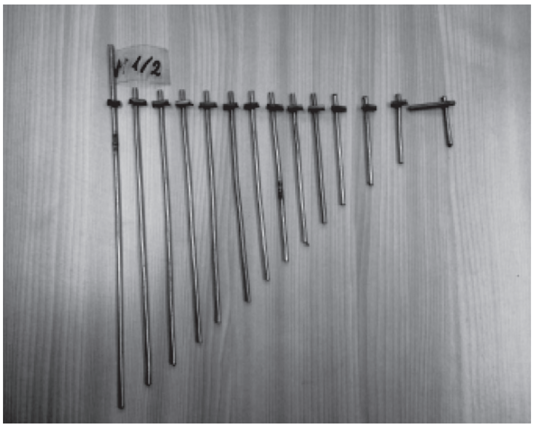

Figure 10. Specimens made from final product

5. Summary and conclusions

Simultaneous measuring of welding parameters (effective current, voltage and time) enabled the determination of in function of time variable resistance of welding joint. Applying the values of measured effective current and voltage moreover the calculated values of resistance the energy of welding and electric power were determined.

On the basis of connection between needed energy quantity and strength of welded joint the optimized welding parameters were determined. At the highest strength the used energy quantity became the optimum moreover its electric parameters became the optimal set values.

Knowing these optimal values, for arbitrary number of nodes and thick wires parameter intervals can be deter-mined which ensure reliable welding joints.

References

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Calendar of international and national events /

Calendarul manifestărilor ştiinţifice şi tehnice internaţionale şi naţionale

2013			
04-05 Jun.	AWS - Pipelines Conference	Houston, United States	http://www.aws.org/conferences/2013pipeline.html
24-26 Jun.	6th ECCOMAS Thematic Conference on Smart Structures and Materials (SMART2013)	Turin, Italy	http://www.mul2.polito.it/smart13/
25-26 Jun.	Exhibition RUSSIA ESSEN WELDING 2013	Moscow, Russia	http://www.sus-me.ru/
08-10 Jul.	7th Asia Pacific IIW International Congress	Singapore	http://iiwcongress2013.com/
11-12 Jul.	The 10th International Conference Structural integrity of welded structures	Timişoara, Romania	http://www.isim.ro/iscs
10-12 Sept.	Materials Testing 2013	Telford, UK	http://www.materialstesting.org
11-17 Sept.	66th IIW Annual Assembly and International Conference	Essen, Germany	http://www.iiw2013.com
27-29 Oct.	2013 CWA Conference	Niagara Falls, ON, Canada	http://www.cwaevents.org/canweld
18-21 Nov.	FABTECH 2013 - Metal forming, fabricating, welding and finishing event	Chicago, United States	http://www.fabtechexpo.com/