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QUALITY MONITORING AT FUSION WELDING OF POLYETHYLENE HIGH-DENSITY PIPES

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Preliminary Note – Prethodno priopćenje

The paper presents the main parameters of fusion welding and their Off - line analysis of Polyethylene high-density (PE-HD) pipes. By direct measurements of voltage and current at the coupler, inductive and the resistant character changes in amplitude modulation waveforms of the measured signal are observed. In early measuring device analyzes the scanned parameters with certain types of fittings and compares them with the tested and measured parameters is done by welding machines. There can be seen the time delay or "dead time" when the system analyzes the parameters and dimensioned regulatory function of the system.

Keywords: Fusion welding, PE-HD pipes, coupler, measured welding parameters

Nadzor kvalitete elektrofuzijskog zavarivanja polietilenskih cijevi visoke gustoće. U radu se prikazuju glavni parametri fuzijskog zavarivanja te njihova Off – line analiza PE-HD cijevi. Izravnim mjerenjem napona i struje na spojnici induktivnog i djelatnog karaktera uočene su promjene u amplitudnoj modulaciji valnih oblika mjerenih signala. Početkom mjerenja uređaj analizira skenirane parametre sa pojedine vrste spojnice i uspoređuje ih sa ispitanim i izmjerenim parametrima koje je odradio sam uređaj za zavarivanje. Upravo se tu vidi zadrška u vremenu tzv. „mrtvo vrijeme" kada sustav analizira parametre i dimenzionira sustav regulatorske funkcije.

Ključne riječi: elektrofuzijsko zavarivanje, PE-HD cijevi, spojnice, mjerni parametri zavarivanja

INTRODUCTION

Connecting polymer materials welding is a common way to connect the PE-HD specific pipe joints. Since polymer materials have been successfully welded a thermoplastic, which, like metals, soften when heated and the tale, and when cooling stiffens, which can be repeated. When we increase the temperature process of welding thermoplastic materials flowing that leads to softening of their (weak secondary bonds). With further increase of temperature leads to melting of plastic materials (secondary bonds discounts and comes to the smooth motion of entire chains of molecules). Rise the temperature causes the melting, and it gets thermoplastic condition where is possible to enforcement welding as a result surface diffusion of molecules. Cooling of welded pieces comes to establishing a secondary bonds and return to the solid state. In order to realize a high quality compound is necessary to perform some preliminary work involving the preparation of welding, including check the correctness of welding equipment and creating the necessary favourable weather conditions. Block classification connection techniques of polymer materials is shown on Figure 1. Other examples of joining the polymeric materials are not analyzed.

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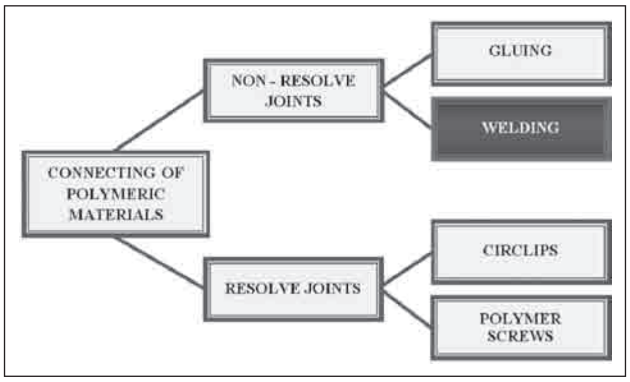


Figure 1 Block classification connection techniques of polymer material

FLOW OF BUTT WELDING PROCEDURE

Flow of butt welding procedure is defined through next steps. Pipes from the high density polyethylene and welded joints using resistance welding wires embedded in the inner part of the coupling. By the flow of the current resistance wire is heated and creates pressure on the connecting surfaces. This leads to fusion of materials, pipes, couplings and their connections. When the snap saddle is welded, welding pressure is provided with the appropriate device in the form of clamp as part of the saddle. Basic requirement that must be fulfilled is that the materials which are being welded are the same hardness and melting index must be from 0,3 to 1,3 g/min. The process is characterized by a high level of automatization. Electro weld sleeve couplings is equipped with a magnetic card on which are registered all welding parameters. Preparation of work area, weld itself and preparing for the welding is similar to that in welding the heating plate. Preparation of ends just before welding involves placing a pipe i.e. connecting pieces in the hydraulic jaws (Heating plate). It is necessary to ensure parallelism plan of the welded surfaces. Mechanical cleaning and degreasing of pipe surfaces which are close to joining point should be ensured as well as the ends of the pipes, by removing particles (milling), Figure 2 a. Join of the saddle pipe and welding machine is shown in Figure 2 b. Removal of possible residual dust is also necessary as well as control of surfaces using parallelism plan by bringing together welded elements. Two main important parameters are also feed check of the pipe panel (up to 10 % of the panel thickness) and the temperature of the body couplings.

After the cooling operation we obtain a high quality junction shown in the cross section Figure 3. In the Figure 3 are visible contact joints of power supply and coil windings elements along the weld.

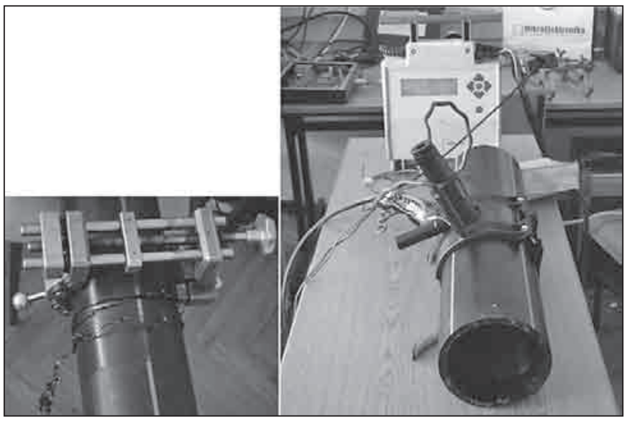
Automatic electric welding machine is equipped with a barcode reader, AC cable and cable fusion for voltages 8-42 V. Figure 4 describe welding machine MSA 350 used in experiments. Graphical interface showing the status during welding, when the keys are meant for different configuration modes.

EXPERIMENTAL RECORDING OF WELDING PARAMETERS

Main welding parameters are voltage and current on joint or saddle. Collecting of measurement parameters is done by measuring card and corresponding elements of the measuring system [1], Figure 5. The monitoring system can record data in real time. In addition to recording in real time, it is possible to working "On-line" and "Off-line" data analysis. Indirect analyses, (Off-line) from the measured parameters are calculated by the current value of resistance, power and energy used for fusion welding.

In the first experiment is used joint of 63 mm diameter, while in the other three types of joints are used 32 mm, 160 mm and 225 mm diameter. Measurement results are showed on the amplitude modulated signal of voltage and current, Figures 6 and 7.

On the basis of the parameters from scanned barcode, information of specific joint was obtained for resistance coil. Due to the fact that the joint and the saddle both incorporates the coil, besides the active resistance there is inductive component that comes to expression, Figure 8. In time frames that are observed as critical



a) b)

Figure 2 Surface preparation for welding:
a) mechanical cleaning; b) join of the saddle pipe

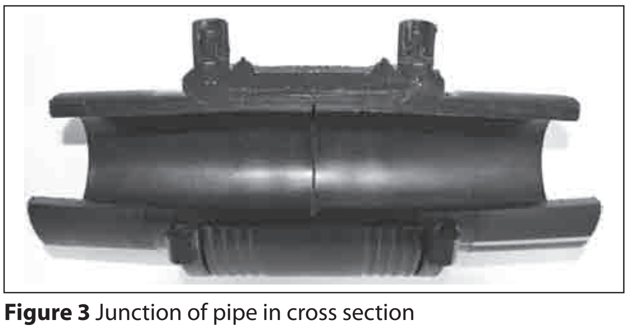


Figure 3 Junction of pipe in cross section

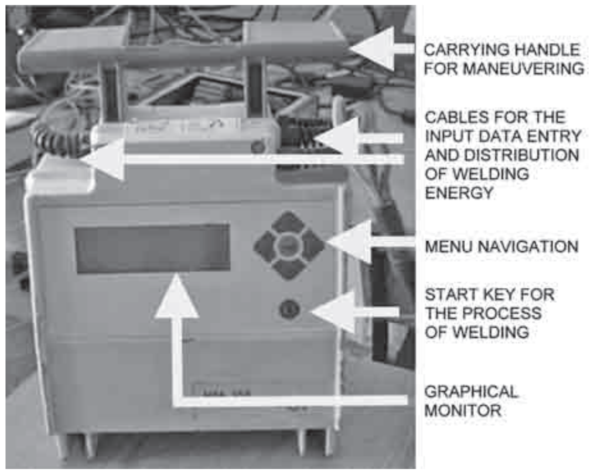


Figure 4 Welding machine MSA 350

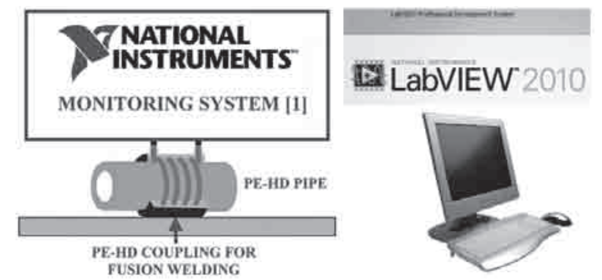


Figure 5 "On - line monitoring system" for recording fusion welding parameters [1]

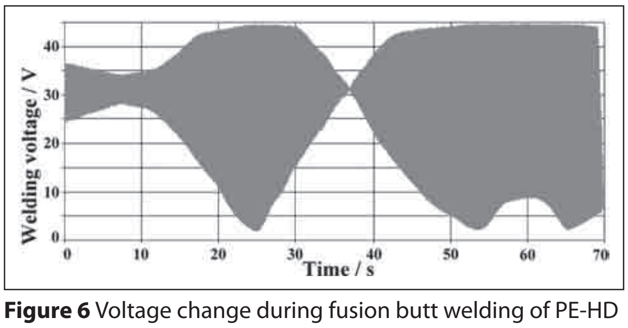


Figure 6 Voltage change during fusion butt welding of PE-HD pipe

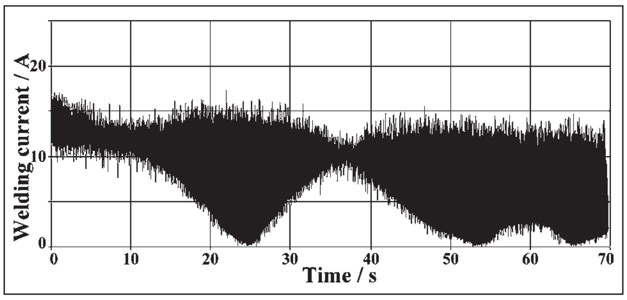


Figure 7 Current change during fusion butt welding of PE-HD pipe

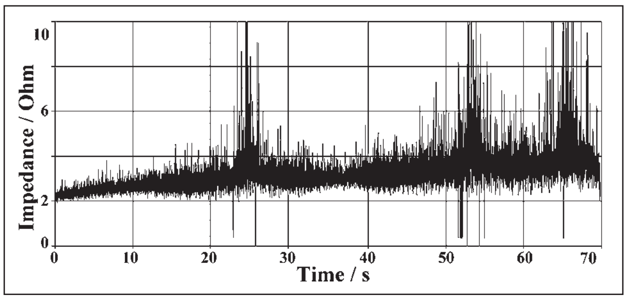


Figure 8 Impedance change during fusion butt welding of PE-HD pipe

intervals, compensations of the inductive component occurs as 25 s, 53 s and 66 s.

If we assume that the automatic machine for fusion welding has defined regulator with predetermined parameter, welding time (in this case to the 70 s), and the envelope graphs of the voltage, current are re-dispersed in 37 s of process. That interference *Z'*, Figure 9, represents the change of impedance *d(Re+jC)* which occurred due to the fed of voltages and variable modulated AM (amplitude modulated) signal. Due to the dissipating heat effect on the lining of the joint, dynamic changes in the parameters are performed. Varying the parameters of the internal electronics machine automatically is compensated by G_R function block (regulator function). Element of the feedback is current measured by the machine, indirectly. Further sequence of modulation and appearance of the envelope precisely depends on that current in terms of oscillatory or dispersed controlled transfer function G_S function block (regulator function) response.

The second set of experiment measurements was done with three joints. Types of joints in this case are 32 mm, 160 mm and 225 mm diameter. Voltage level for 160 mm and 32 mm are measured, Figure 10. The process of preparing for the welding was previously explained. Contact surface of the pipe must be cleaned by scraper and alcohol tissue. In addition, it is very important that contact surface of the pipe has best possible overlap or the bigger surface contact. By scanning the barcode on the individual joints or saddles the predefined parameters of manufacturer are written to main memory unit of welding machine. After entering the parameters, by pressing the start button examination system of dynamic parameters will be activated as well as welding process itself. In the time interval from 0 – 200 ms was measured the low signal voltage. This result indicates that in mentioned interval device automatically brings a certain voltage and considering the feedback it calculates additional dynamic parameters. Welding voltage for 160 mm, Figure 10 a), and current Figure 11 a), represent calculated impedance Figure 11 b).

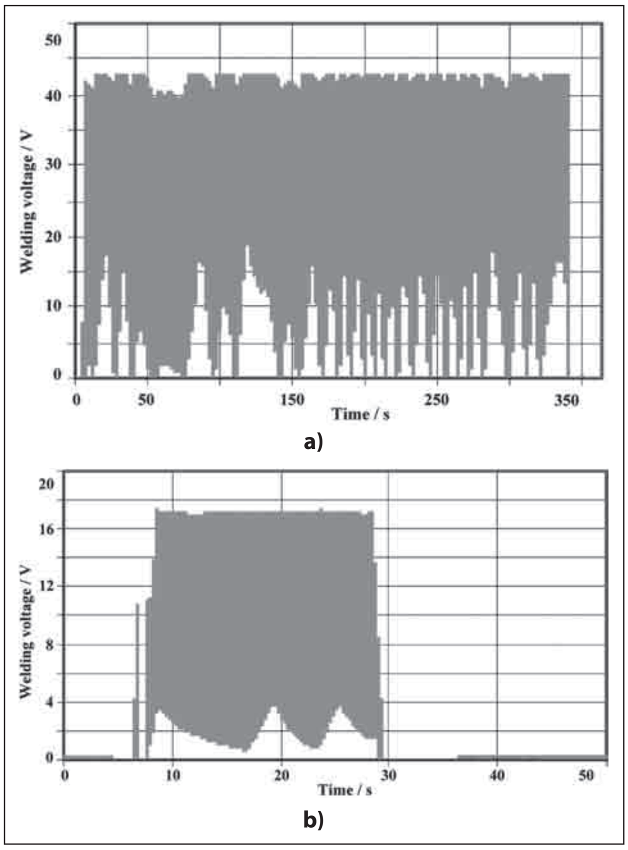


Figure 10 Measured values of voltages for a pipe diameter a) 160 mm, b) 32 mm

When a device estimates parameters and creates its own mathematical model according to static and dynamic parameters automatic regulator is created. This regulator performs fusion welding of characteristic length depending on the diameter of the welded joints or other connecting elements.

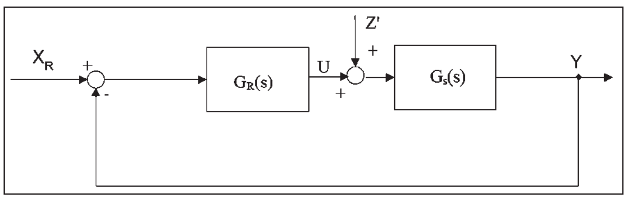


Figure 9 Regulation system with transfer function and interference Z'

CONCLUSION

Using two welding machines of the same producer with same scenarios measurement results are compared with the identical set of welding parameters [3]. In first experiment is used 63 mm pipe diameter, where are represented results of voltage and current directly like envelop of amplitude modulation. Indirectly (Off-line) is

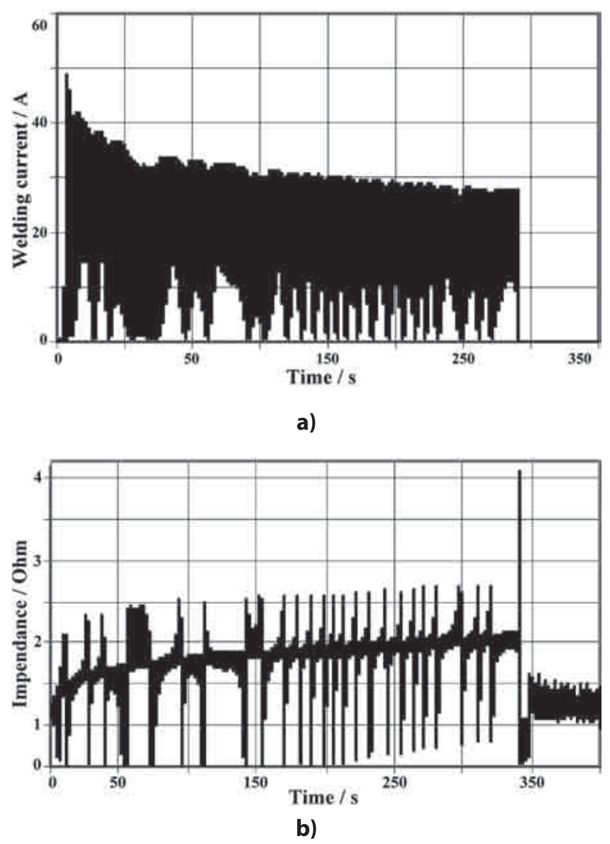


Figure 11 Measured values of a) current ; b) "Off-line" calculated impedance for a pipe diameter 160 mm

analyzed power and impedance. Second experiment contains pipes of 32 mm, 160 mm and 225 mm. With smaller diameter of pipes this part has less-time welding. By increasing the pipe diameter proportionally welding time is also increased. Closed system of regulation is obtained during welding while preserving the consistency. From measurement results at some point, comes to decreasing values of voltage. This is an indication that system would be cooled down to prevent inflammation. After cooling, the system is reactivated on the nominal power by using amplitude modulation of voltage and current. From experimental part we can conclude the following; the observed process is stable, the repeatability of the parameters is provided, and ability to detect errors in the event of failure of joints or any other element of the system and data storage. The joining process is very reliable and safe. The previous exploration has proven to be very economical for a relatively small diameter of pipe [4]. Welding control in this paper was done using subjective method. Figure 3 shows cross-section and weld quality [5]. Categorization of the specific polyethylene electrofusion welding satisfies required norms for welding quality with the used welding machine [6].

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