Determining the Temperature Field at Welding the Polyethylene Sockets

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The present paper aims to examine the way in which the temperature is distributed when the polyethylene sockets are welded using the electrofusion procedure. This research is necessary because in practice certain problems occur relating to the destruction of these sockets during welding or later. The survey is conducted in cooperation with companies working in the field of welding in polyethylene, complying with the required standing standards.

Keywords: polyethylene socket, temperature field, dangerous area

The efficiency of a pipeline system depends, besides the cost of pipes and fittings, on the cost of installation, on the cost of maintenance and on the lifespan. The advantages of using the polyethylene pipes (fig. 1) for the transport and distribution of natural gas as opposed to the steel pipes, may be highlighted through numerous features [1-3].

The development of thermoplastic materials (polyethylene, polypropylene, polymerized vinyl chloride) had a special amplitude in the last 50 years [4].

The increased mechanical strength of the polyethylene pipes and thus the increased internal pressure of operation have the following consequences:

- The reduction of the wall thickness, with important economical effects [5, 6];
- The increase of the productivity of the pipe extrusion operation [7, 8];
- The decrease of the residual stresses caused by the welding operation;
- The possibility of installing pipes in soft soil without a sand bed [2].

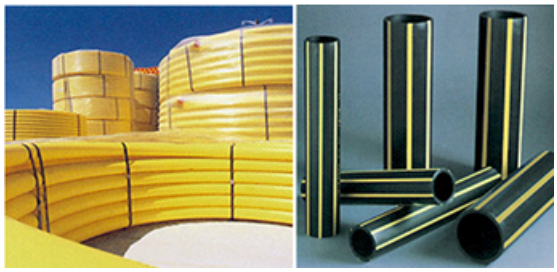

Fig. 1.Polyethylene pipes used in the natural gas distribution systems [9, 10]. a – coiled pipe; b – straight pipe.

Fig. 2.Welding and temperature measuring system

Fig. 3. Welding the polyethylene pipe PE 100 SDR 11 to the polyethylene sockets for the following diameters: a. DN 32; b. DN 63; c. DN 90 mm

Experimental part

Welded instalations for different dimensions

The conducted study required the following equipment (fig. 2): 1. Welding machine for welding polyethylene Sbox, manufactured by Fusion company in England, which enables the welding of polyethylene fittings up to 180 mm in diameter and has the capacity to monitor the welding cycle, so that in case it is not completed correctly, the machine will register and highlight the error in the welding protocol; 2. High technology camera for recording the temperatures, ThermoVision A320, which enables the measurement and listing of temperatures both in an overall area and on an area of interest; 3. Software for the acquisition of the values measured using the thermal camera – it allows us to create an overall or detailed image of the assembly. 4. The welding system which is composed of the SDR11 high density polyethylene pipe with the diameter of DN 32, 63, 90 used in the natural gas distribution and the polyethylene sockets 32, 63, 90 mm in size.

The welding technology is followed and the tools and machines used are certified. The marking on the pipe was made, the metallic scraper was used to remove the coating from the DN32, 63, 90 mm pipe in the welding area, this area was etched with a special etching solution, and then the electrofusion DN32, 63, 90 diameter sockets were fixed and the welding procedure began.

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All authors have equal contributions to the study and the publications

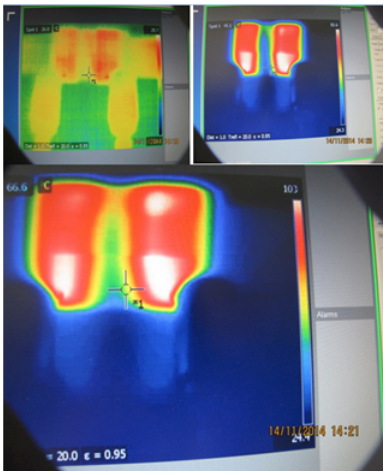

Fig. 4. Highlighting the temperature increase in the three welding stages for the DN 32 diameter: a. Initial; b. Middle; c. Final under correct working conditions

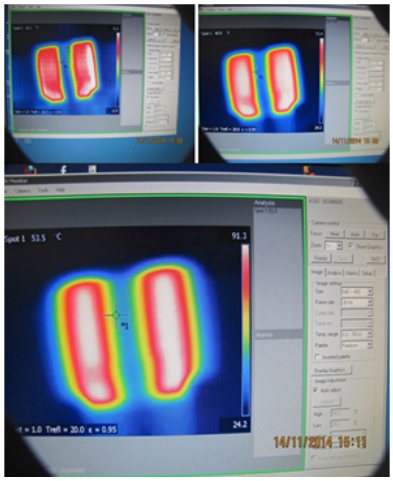

Fig. 5. Highlighting the temperature increase in the three welding stages for the DN 63 diameter: a. Initial; b. Middle; c. Final under correct working conditions

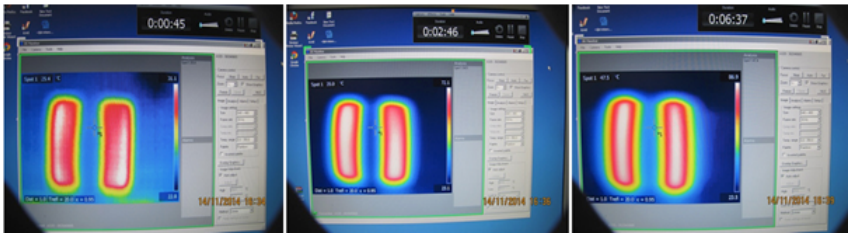

Fig. 6. Highlighting the temperature increase in the three welding stages for the DN 90 diameter: a. Initial; b. Middle; c. Final under correct working conditions

Table 1

TIME AND TEMPERATURES MEASURED DURING THE ELECTROFUSION WELDING PROCESS

Time [s]	DN 32	DN 63	DN 90
0	0	0	0
20	29.7	33.1	31.1
40	32.9	47.4	36.6
60	42.0	60.2	44.6
80	49.5	67.3	51.9
100	58.2	73.4	59.1
120	66.3	77.6	65.7
140	73.4	81.6	70.9
160	81.6	84.2	72.1
180	87.8	88.1	75.0
200	93.9	91.3	78.5
220	96.2		80.9
240	98.6		82.6
260	101.0		83.9
280	103.0		86.9

Conducting measurements by means of the thermographic camera

Measurements on the work assemblies (3 tests) were carried out at an ambient temperature of 22 Celsius degrees. The Sbox polyethylene welding machine allows the automatic adjustment of the operating voltage and the progressive increase of the welding temperature, which is seen in the following images taken during the measurements.

The study was intended for highlighting the welding of the three most used PE 100 - SDR 11 pipe diameters: DN 32, DN 63, DN 60 (fig. 3).

Results and discussions

Following the measurement of the temperature during the welding process, we may point out that: the time required for welding the DN 32 fitting is 45 s, the time required for welding the DN 63 fitting is 35 s and the time required for welding the DN 90 fitting is 80 s, times automatically set by the welding machine, which receives the information from the fitting and makes this adjustment automatically. The time until the temperature rose and stabilized is shown in figures 4-6. In terms of the differences between the welding temperatures, they were related to the maxima obtained for welding the DN 32, at a temperature of 103 Celsius degrees, the 63 DN reached a maximum of 91.3 Celsius degrees and the DN 90, the peak was 86.9 Celsius degrees (table 1 and fig. 7).

The usual way in which high density polyethylene pipelines under pressure are damaged is the appearance and then the expansion/ propagation of cracks in the fragile material area. The design of the polyethylene pipes cannot be based on the short-term test results, because of the influence of the long term operation factors, primarily creep and pressure fluctuations. Also, an important role is played by the fittings required for joining pipes made of polyethylene or other materials, namely steel [11-14].

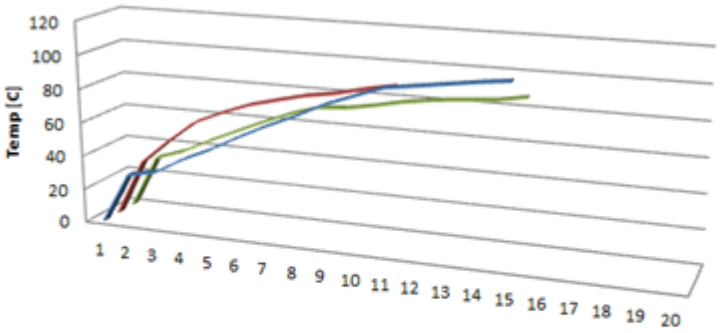

Fig. 7.Variation of the temperature in the welding area depending on time [s] for the three welding cases.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
Series1	0	30	33	42	50	58	66	73	82	88	94	96	99	101	103					
Series2	0	33	47	60	67	73	78	82	84	88	91									
Series3	0	31	37	45	52	59	66	71	72	75	79	81	83	84	87					

Conclusions

Following the conducted studies, the important aspects listed below were noted:

- this work aims to highlight issues related to the correct welding method and the problems arisen in achieving the welding;
- it presents the method of performing electrofusion welding for three types of frequently used diameters;
- the problems encountered in practice were taken into account and tried to be avoided during the execution of the tests;
- the welding was performed by personnel authorized by the State Inspection for Control of Boilers, Pressure Vessels and Hoisting so that the obtained results could be validated;
- it was observed that the time required for welding the DN32 socket was 45 s, for the DN63 socket was 35 s, and for the DN90 socket was 80 s;
- the time required for the DN32 socket to heat was 280 seconds; it took 200 seconds for the DN63 socket to heat and 280 seconds for the DN90 socket;
- the maximum temperature reached by the DN32 socket was 103 Celsius degrees, by the DN63 socket was 91.3 Celsius degrees, and by the DN90 socket was 86.9 Celsius degrees;
- it is recommended to use a device to fix the sockets, which will maintain the angle between the pipes and the sockets at 0 degrees, thus increasing the safety in operating the high density polyethylene fittings and pipes.

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