Heated Tool Butt Welding Of PE Pipes

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Abstract: *The paper shows a part of the investigation results of the heated tool butt welding of PE100 pipes, with a diameter Ø160 mm and with thickness of 8.00 mm.*
Wildings were performed on several tests, during which a part of the parameters of the welding regime were changed. Changes were made over the time of heating of the tool, time of affection and intensity of pressure of the pipes over the tool – plate.
Serial of examinations for establishing the quality of the welded joint were performed over the tests. A visual control and test of resistance to internal pressure was performed.
Test specimens were made from the welded pipes and a tensile and bending test was performed.

Key words: *polyethylene pipes, PE 100, butt welding, heated tool – plate*

1. Introduction

The use of pipe installations of plastic, polymer materials: pipes, knees, pockets etc have been more and more implemented. For production of pipes and pipe elements the most used polymer materials are: the polyethylene (PE) and polyvinylchloride (PVC), also polyamide (PA) polypropylene (PP). [1.2]

The joining in production and installation of polymer elements is usually performed by welding. According to DIN 1910 part 3, depending on the heat source welding of polymers can be performed by: heated tool, heated gas, light beam, ultrasonic, friction and high frequency heating. [3]

Welding of polymers is performed by combinations of heat and pressure, with or without use of a filler material, depending on the shape of the joint and the thickness of the basic material.

The development of the polymer welding begins in the year of 1935 with the discover of polyvinylchloride (PVC). On 180^{o} C PVC is in thermoplastic condition and by use of pressure homogeneous joint is achieved. In 1938 welding by heated gas was patented. In the second half of the fifties begin the intensive development and implementation of the automatic polymer welding. [4.5]

The last ten years the research of polymer welding has become more intensive, because of the wider use of the polymer materials in the production of important elements, as well as development of new kinds of polymer materials and new technologies for their welding, like laser welding or hybrid polymer welding by simultaneous perform of the laser beam and other heat source. [6.7]

Confirmation of the increased interest for research in this welding field is the fact that from the beginning of 2007 DVS has begun with editing of a special scientific – professional journal under title Joining plastics (Fügen von Kunststoffen), where the latest scientific achievements are being presented. Few years before that, from 2004 to 2006 were issued more expert books about polymers and their joining. [6.9]

2. Heated tool butt welding

This procedure is used for welding of polymers in shape of plates or pipes. In the case of plate the joining is performed by heated tool butt welding or by overlapped welding, and in the case of pipe joining it is performed by heated tool butt welding or by overlapped welding so called telescopic weld.

The surfaces that are joining are being heated until soften, with the help of the heated tool, which can have

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different shape: plate, ring etc. The tool is heated most frequently by electrical resistance.

Depending on the shape and the dimensions of the welded elements, this procedure can be performed manually, mechanically or automatically with a special welding device.

The welding processes it self is performed in several phases, shown on Fig. 1. At the beginning the pipes are being put in two part bends clamps for accepting (a), after that it moves and makes alignment of jointing surfaces (b). In the next phase the pipes are being separated and between them we position fitting with a milling cutter which simultaneously makes alignment of both of the pipes, which are at the same time pressured with a constant strength of the tool. After the planned heating time is passed, the plate is released and the heated and softened jointing surfaces again are pressured one to another, with certain pressure in certain time (e), after what the pipes are being released from the bends clamps and that means that the welding is finished (f). The process of welding is performed in time measured from several seconds to several minutes; it depends on the type of the polymer, the shape and the dimensions of the welded pipes.

3. Sample butt welding

Heated plate tool butt welding was performed on polyethylene pipes of PE 100, with external diameter Ø 160mm and thickness of the wall of 8.00mm.

The welding was performed according to the regime defined in DVS 2207-1, [9], having in mind the recommendations of the welding equipment producer. The welding regime is chosen depending on the type of the polymer, the shape and the dimensions of the welded samples, the area of the cross section that is being welded.

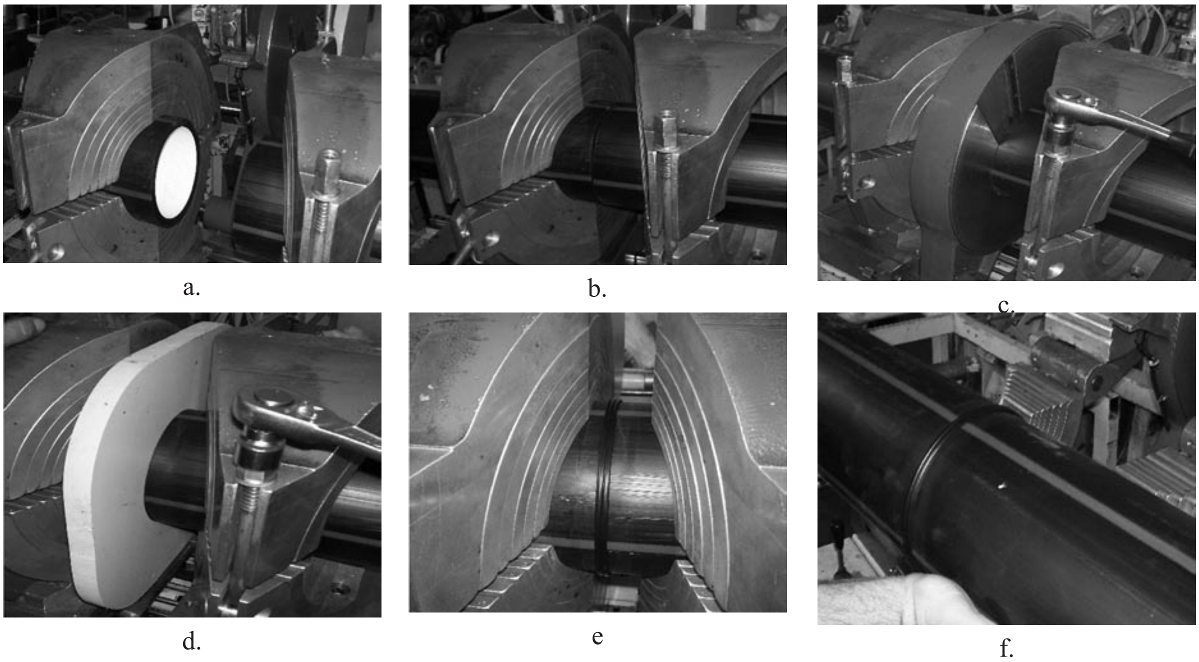

Fig.1. Phases of heated tool plate shaped butt welding

Fig.2. shows a graphic representation of the welding regime, with all the welding phases and the changes of the temperature and the pressure during time.

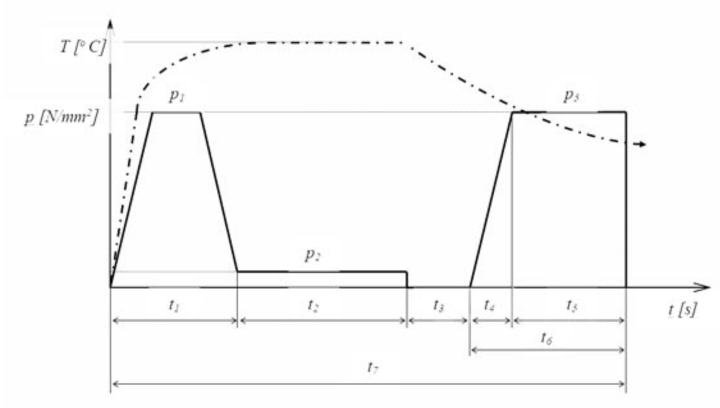

Fig.2. Regime of heated tool plate shaped butt welding

The welding regime is consisted of the following parameters:

T [° C] – heating temperature of the tool – plate,
p_1 [N/mm²] – jointing surfaces pressure on the heated tool during the alignment,
p_2 [N/mm²] – jointing pressure on the heating element,
p_5 [N/mm²] – pressure between the jointing surfaces during cooling time,
t_1 [s] – alignment of jointing surfaces,
t_2 [s] – time of preheating of the jointing surfaces,
t_3 [s] – time of the removal of the heating plate,
t_4 [s] – time to achieve jointing pressure,
t_5 [s] – cooling time of the pieces to be welded at jointing pressure,
$t_6 = t_4 + t_5$ [s] – welding time.
$t_7 = t_1 + t_2 + t_3 + t_6$ – total welding time.

Larger number of samples was welded, some of the parameters were with constant value, and others were changed in different levels.

Constant parameters were:

T = 210 ° C – heating temperature of the tool – plate,
p_1 = 0.15 [N/mm²] – jointing surfaces pressure on the heated tool during the alignment,
p_2 = 0.38 [N/mm²] – jointing pressure on the heating element,
t_{1max} = 8 [s] – alignment of jointing surfaces,
t_{3max} = 8 [s] – time of the removal of the heating plate,
t_5 = 18 [min] = 1080 [s] – cooling time of the pieces to be welded at jointing pressure Variable parameters:
p_5 = 1.9 – 2.3 [N/mm²] – pressure between the jointing surfaces during cooling time,
t_2 = 112 – 124 [s] – time of preheating of the jointing surfaces,
t_4 = 7 – 9 [s] – time to achieve jointing pressure,

Welding of the samples was performed by combination of the variable welding parameters given in table 1.

Tab.1. Samples welding regime

	P1	**P2**	**P3**	**P4**	**P5**	**P6**	**P7**	**P8**	**P9**
t2 [s]	112	124	112	124	112	124	112	124	118
t4 [s]	7	7	9	9	7	7	9	9	8
p [N/mm²]	1.9	1.9	1.9	1.9	2.3	2.3	2.3	2.3	2.1

4. Investigation of the welded samples

More examinations were made upon the welded samples for establishing the quality of the butt weld. A visual control of the weld was performed upon all of the samples, according to DVS 2202-1.

The mechanical examinations of share strength and bending were performed on a standard specimen made from each welded sample. The examination of share strength was performed according to DVS 2207 part 5 and DIN 53455, the examination by bending was performed according to DIN 53452.

An examination of impermeability by inner pressure according to ISO 1167 was performed upon special welded samples, combining the parameters like: P1, P8 and P9.

5. Results and analysis

By visual control of the welded samples and the control of the longitudinal cut samples, from in and outside, flash shapes were noticed at the jointing, fig. 1e and 1f. No mistakes were established at the weld and its surrounding, according to DVS 2202-1.

During the examinations by share strength all the samples broke at the basic material far from the welded jointing, Fig 3.

Fig.3. Share strength examined samples

The maximal hardness of the tested samples is in the interval Rm = 21,25 -22,24 N/mm^2, which are the standard values for this type of material. Capacity of the welded joint is bigger than the capacity of the basic material and the welding does not change the capacity of the basic material.

During the examination of bending 22 of total 27 welded samples, were bended without breaking to angle of 160^o, which is in the interval of standard values for this type of material. Three samples showed a crack in the welded joint at angle of 120^o, and 2 samples showed a crack in the welded joint at the beginning at angle smaller the 10^o, Fig.4.

Fig.4. Samples examined by bending

Three separately examined samples, according to ISO 1167, were examined on water impermeability by internal pressure on 20^{o}C temperature. All of the three samples were prepared by the necessary supports and cups and than were sunk in water pool. The test was finished with a resistance on internal pressure of 2.177 to 2.194MPa during 60 minutes. All the samples resisted the test in determined time without showing of permanent deformations, which confirmed the impermeability of the weld and the basic material.

After the standard test, all the samples were tested on the maximal pressure of the testing installation of 5.00MPa. Permanent deformations were noticed at the basic material, but a break – explosion did not occur, which confirmed the impermeability of the welded samples, Fig. 5.

Fig.5. the samples before and after the examinations on impermeability

6. Conclusion

Butt welded joint of polyethylene pipes performed by heated plate perform a high quality. By use of optimal parameters in the welding regime we get a welded joint without mistakes, with hardness higher than the hardness of the basic material, and flexibility like the basic material, impermeability like the basic material.

Considering the high quality of the welded joint and the high mechanical characteristics, the polymer pipe installations heated tool butt welded can be used as elements in installations under high working pressure.

References

1. Kienle, U., Schweißen von Kunstoffrohrmaterial, Jahrbuch Schweißtechnik ’99, DVS Verlag, 1998, S. 125-134.
2. Renneebrg, H., Schneider,W., Kunststoffe im Anlagebau (Werkstoffe, Konstruktion, Schweißprozesse, Qualitätssicherung), ISBN 3-87155-176-7, DVS Verlag, 1998, S.1-392.
3. N, N., Sacweißen von Kunststoffen – Verfahren, DIN 1910 Teil 3, 1977, S. 118-125.
4. Hessel. J., Land, W., Schwarz, O., Schweißen von Kunstoffen, Jahrbuch Schweißtechnik ’97, DVS Verlag, 1996, S. 235-246.
5. Haberstroh, E., Wolters,L., Stagmaier, M., Kunststoffeschweißen – Teil 1, Handwerkliche Verfahren, Schweissen & Schneiden, Heft 4, 2000, S. 214-224.
6. Potente, H., Fügen von Kunststoffe (Grundlagen, Verfahren, Anwendung), Karl Hanser Verlag München Wien, ISBN 3-446-22755-6, 2004, S.1-348.
7. Wilhelm, G., Handbuch Kunststoff – Verbindungstechnik, Karl Hanser Verlag München Wien, ISBN 3-446-22668-0, 2004, S. 1-754.
8. Franck, A., Kunststoff – Kompendium, Karl Hanser Verlag München Wien, ISBN 978-3-8343-3085-7, 2006, S. 1-504.
9. N, N., Taschenbuch DVS-Merkblätter und – Richtlinien Fügen von Kunststoffen, DVS Verlag, ISBN-13: 978-3-87155-217-5, ISBN-10:3-87155-217-8, 2006, S. 1-790.