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Comparative Theoretical and Experimental Study between Electrofusion Welding and Gluing the Fittings to the Polyethylene Pipe with Adhesive: Part 2

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Abstract: ***The paper aims to conduct a comparative experimental study between a traditional method of fastening a fitting to a polyethylene pipe - welding, and the method suggested to be studied - fitting injected with adhesive.***

Keywords: insulation, polyethylene, mechanical action**.**

1. Developing the Physical Model by Rapid Prototyping of the Socket to be Glued

The polyethylene socket was modeled using the Catia software and then imported in the machine's system.

The following figure shows the two parts made on the machine's workbench. It should be noted that the part is made of plastic thread, a material similar to the basic polythene from which the electrofusion socket is made.

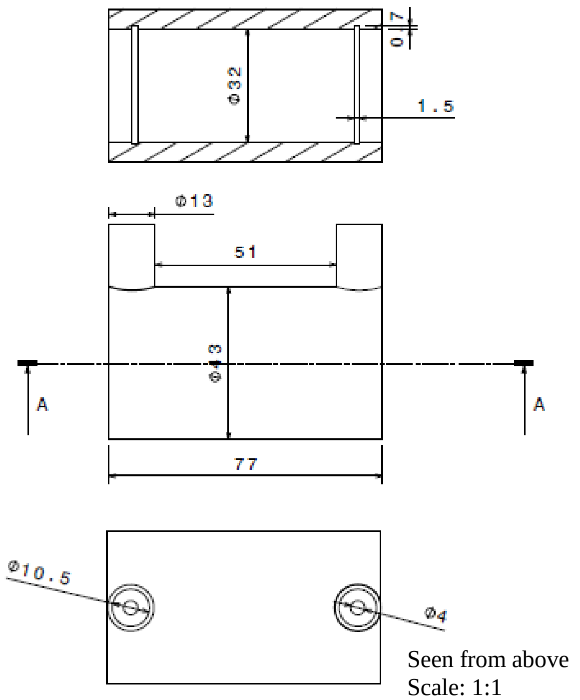

Figure 6: The polyethylene socket drawn in Catia

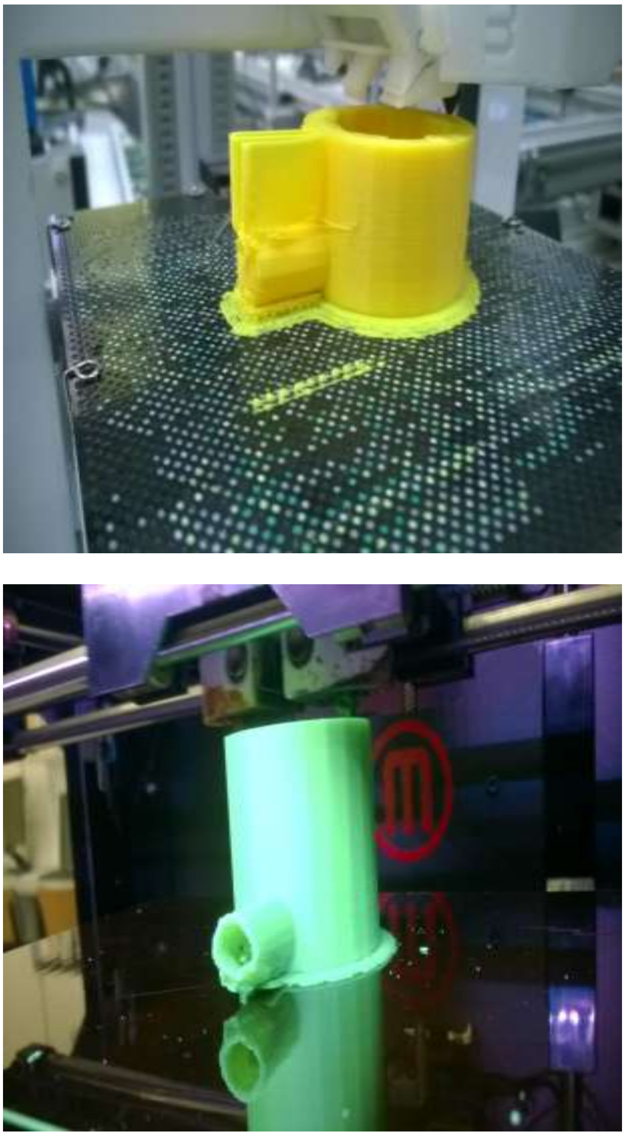

Figure 7: Intermediate stages in developing the fitting

Figure 8: Stages of performing the intended parts

After applying successive layers, the two parts were made, consistent with the dimensions of the initial one, as shown in the following figure.

Figure 9: Parts resulted from rapid prototyping

The advantages of rapid prototyping are the following:

- It allows us to make a physical model regardless of its shape (disadvantage - it is not possible to make large models due to the dimensions of the work tank);
- By using the process, it can be noted that it is rather easy to make small series parts required for repairs;

2. Testing the Fitting - Polyethylene Pipe Sub-Assemblies at Axial Stress

These tests were conducted on the Instron 4303 testing machine. The universal traction, compression and buckling testing machine Instron 4303 is a universal testing tool shown in Figure 10 a, 10,b.

The machine has a maximum load capacity of 25 kN, controlled through the IEEE-488 interface and the specialized Material Testing System series IX software. This universal testing tool facilitates the control of the speed of the mobile crosshead to an accuracy of 0.5% and the recording of the force with a precision corresponding to class ASME 4-E or DIN 51221 Class 1.

The mobile head's control system makes possible to program the moving crosshead's speed and assures the control of the mobile head's position.

The resulting data are specific to the test types for which the machine was built, covering loads, displacements, stresses, specific strains, energies. During a test, the results appear as instantaneous values of the load and of the displacement or stress and specific strain, and at the end of the test, they appear as peak values or registered in the points specified by the user.

Figure 10 (a): The traction, compression and buckling testing machine Instron 4303.

The power supply of the Instron machine is controlled by a switch (1). In order to avoid accidental startup, the machine is provided with a mushroom-headed button (2) and it contains two grips for clamping the two rams: (3) for the stationary ram and (4) for the mobile ram. The moving crosshead (6) moves vertically by means of the ball screws (8) mounted on the fixed frame (16) and protected against blows, dust and possible splinters by the protective covers (9).

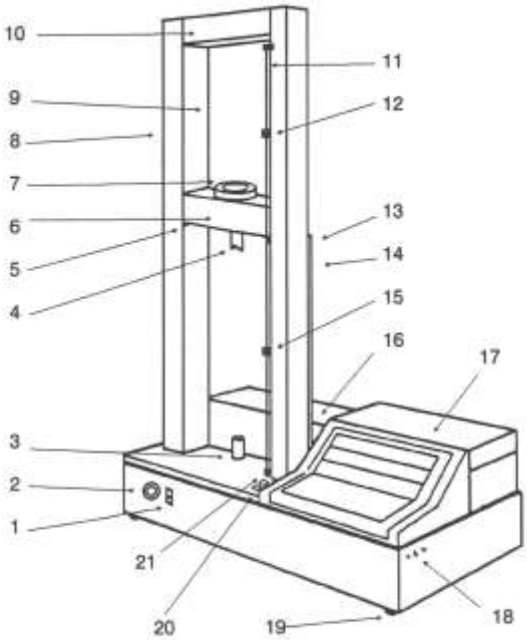

Figure 10 (b): The traction, compression and buckling testing machine INSTRON 4303.

The fixed frame is stiffened by means of the fixed crosshead (10) located at the top of the machine. The transducer for measuring the force (7) and the limit ring that avoids loading the machine with a force exceeding 25 kN (5) are mounted on the moving crosshead. Parallel to the two columns of the fixed frame are two rods at the end of which there are two limit rings which are designed to avoid hitting the moving crosshead on the fixed crosshead (11) and the lower part of the fixed frame (21). On these two rods there are also two other mobile limit rings that delimit the working area of the machine according to the size of the work stroke (12, 15). The transducers for measuring displacements (13) and the connectors used for passing the information from the transducers to the measuring system (14) are mounted on the right-hand column of the fixed frame. On the right of the columns is the Instron 4303 console (17) used for setting the movement, loading and moving speed of the moving crosshead. The console is also used for connecting the IEEE interface to the computer. The console is provided with a locking system (18) to prevent accidental startup during transport. The machine is provided with four supporting legs (19) for adjusting its position. This must be parallel to the ground in order to avoid the occurrence of measurement errors. There are two buttons next to the work console which allow the fast ascent and descent of the moving crosshead to facilitate the positioning of the clamping jaws at the first test.

The obtained data can be plotted directly in the force-displacement coordinates. However, they are generally converted into stress-strain coordinates.

The testing program is based on the following:

- 10 specimens were made;
- A testing method has been developed in the INSTRON test machine's own language, namely the MATERIAL TESTING SYSTEM.

Figures 11 and 12 show the specimens used for the testing and the actual testing methodology on the INSTRON 4303 testing machine.

Figure 11: Specimens made for testing

Figure 12: Fastening the pipe in the rams of the testing machine

Table 1: Experimental results for Φ 32 x 3.0 pipe made of PE 100

N	Width of specimen	Thickness of specimen	Cross section area	Length of specimen	Testing speed	Maximum force	Fracturing force	Maximum elongation	Maximum strain
Nr. crt.	**Lătimea epruvetei**	**Grosimea epruvetei**	**Aria sectiunii transversale**	**Lungimea epruvetei**	**Viteza de încercare**	**Forta maximă**	**Forta de rupere**	**Alungirea maximă**	**Tensiunea maximă**
	b [mm]	**h [mm]**	**S_0 [mm^2]**	**L [mm]**	**V [mm/min]**	**F_{max} [N]**	**F_r [N]**	**ΔL_{max} [mm]**	**σ_{max} [MPa]**
0	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1.	6,2	3,0	18,6	100	100	388,2	377,4	265,5	20,9
2.	6,4	3,0	19,2	100	100	444,8	442,1	281,2	23,2
3.	6,4	3,1	19,8	100	100	432,3	423,2	272,2	21,8
4.	6,3	3,0	18,9	100	100	442,1	439,5	292,3	23,4
5.	6,4	3,1	19,8	100	100	434,1	431,4	284,8	21,9
Media aritmetică (x_{med})						**428,3**	**422,7**	**279,2**	**22,2**
Abaterea pătratică medie (s)						**23,0**	**26,4**	**10,5**	**1,05**
Coeficientul de variaţie (CoV)						**5,38**	**6,24**	**3,77**	**4,70**

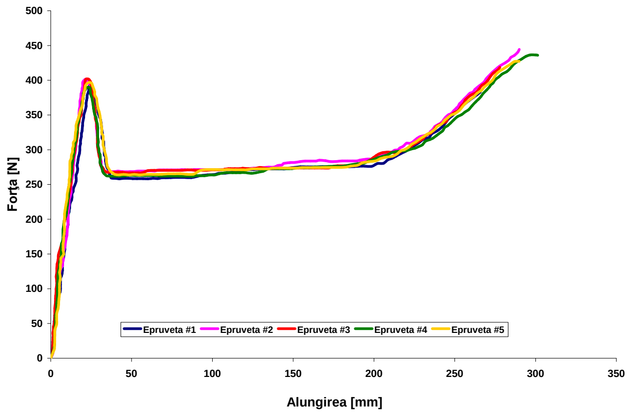

Figure 13: Specific curbes force-elongation for the pipe specimens Φ 32 x 3.0 made of PE 100

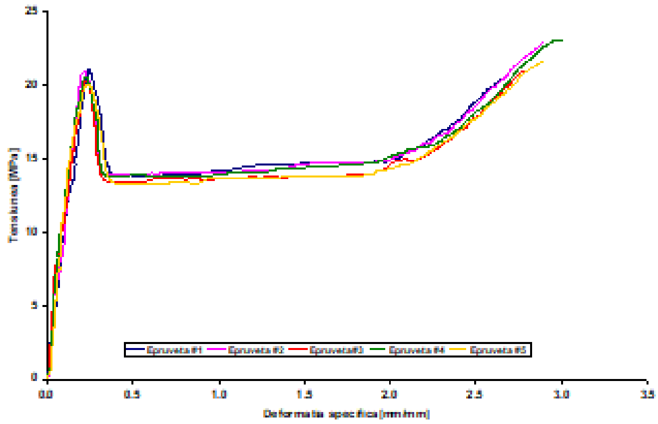

Figure 14: Stress-strain characteristic curves for the pipe specimens Φ 32 x 3.0 made of PE 100

Determining the longitudinal elastic modulus

For all the tested specimens whose force-deformation characteristic curves were presented in the previous paragraph were also plotted the characteristic stress-strain, and the longitudinal elastic modulus was determined for each case.

The next figures show the stress-strain characteristic curves for the studied polyethylene pipes.

Based on these characteristic curves, it was possible to calculate the values of the longitudinal elastic modulus, which were presented in the table, and also a statistical analysis was developed (similar to that made for the experimentally determined data for each type of pipe), establishing the arithmetic mean of the determined values, their mean square deviation, and the coefficient of variation of these values.

These experimental data, in particular the characteristic stress-strain curves and the longitudinal elastic modulus will be used in the finite element analysis (simulations).

In order to develop the assembly fitting-polyethylene pipe, a joining procedure similar to that for joining polyethylene will be used, but the gluing will be done by means of an adhesive injected through the two upper elements.

Figure 14: Adhesive will be injected into the plastic fitting in order to perform the assembly through the side controllers

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Author Profile

Avrigean Eugen - holder of a Ph.D. title in Mechanical Engineering, specialty Strength of Materials, higher education faculty member (Lucian Blaga University - Faculty of Engineering) and conducting research for 16 years. He has written numerous research books and articles, and worked on laboratory studies, numerical analysis and computer aided design.