WELDING OF POLYETHYLENE PIPES WELDING, DEFECTS AND THEIR REASONS OBSERVED IN ELECTROFUSION

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1. INTRODUCTION

Because of the high pressure (60 -125 bar) in g as transmission pipes from source to town centers, high -resistance steel pipes are used in these parts of a gas distribution network. The high level o f pressure is then reduced to operating pressure with the help of p ressure-reduction systems in town centers after which gas is d istributed to households and industrial-users through large -diameter polyethylene pipes that are more economical than steel pipes.

In addition, sewage and water organizations are replacing their existing systems with PE pipes. PE pipes are widely used because of the convenience they provide in transmission of gas, which is a flammatory and explosive fuel, into populated areas and also in the way they are laid and connected. The ideal method to connect pipes is welding. Although there are plenty of methods developed for connecting pipes, the most -widely-used methods are electrofusion and butt -fusion welding. Due to the risks involved in case o f a gas leakage through the welded points of PE pipes that transmit natural gas, it is necessary to make the pipe connections with utmost care in accordance with rules and to inspect these connections meticulously afterwards.

For these reasons, welding pro cedures used on PE pipes should be carried out in accordance with the rules prescribed. Well-trained and certified welding operators who are qualified in the welding of plastic materials are also needed. Therefore, both the producing and inspecting organizations have obligations on their part to ensure error -free welding.

2. POLYETHYLENE

Polyethylene is a thermoplastic material used in a wide variety of products. It is called after ethylene in monomer state. Polyethylene is produced by using ethylene and it is usually referred to as PE in plastics industry. The ethylene molecule C2H4 (figure 1) is made up of two cross -linked CH2's. (CH 2=CH2) To produce polyethylene, ethylene is polymerized.(figure 2)

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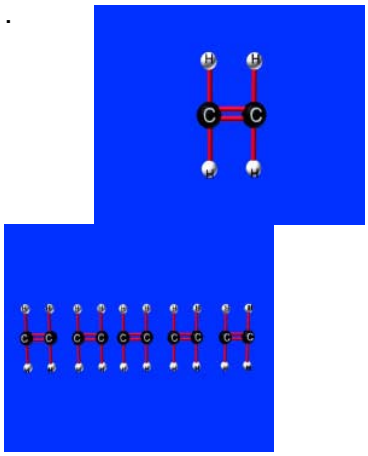

Figure 1: ethylene

Figure 2: polyethylene

2.1. Categorization of PE

Polyethylene is categorized based on its density and chemical features. Its mechanical features are determined by molecular weight, crystal structure and branching type.
-UHMWPE (ultra high molecular weight PE), HDPE (high density E), HDXLPE (high density cross -linked PE).PEX (cross -linked PE), MDPE (medium density PE), LDPE (low density PE), LLDPE (linear low density PE), VLDPE (very low density PE)

2.2. The Features of PE

Even though these features may change according to different types, there are some features common to all types such as good resistance, flexibility, weak mechanical strength and superior chemical resistance. PE is a low-cost material used in a wide range of a reas including containers, kitchenware, plastic boxes, coating, pipes and tubes, toys, insulating layers in cables, packaging and cling film.
PE pipes ar e color -coded based on the purpose of their utilization. Pipes used in gas distribution are yellow while water distribution pipes are blue and sewage pipes are black. This kind of coding brings great convenience in recognizing the regarding network system and preventing possible confusions. These pipes are in fact not different at all in terms of their mechanical features.

Figure 3: Raw material of PE in granules

2.3. The Development of PE

Rapid developments in plastics technology brought about very important developments in raw material production too. PE 63, which was developed in 1953, was successfully used in systems that did not require high pressure. It was only used in systems with low pressure (maximum 4 bar) because of its mechanical features. After PE 63, Producers of polyethylene developed the second generation of this material, PE 80.

These pipes:

-are more durable
-have higher flexibility and a higher coefficient of elongation
-Thanks to these featu res, they can be safely used in areas of landslide and under the sea-bottom.

Figure 4 : Various PE pipes used in infrastructure

The requirements of the advancing technology and some insufficiencies of the raw materials of PE63 and PE 80 led PE prod ucers to do more research and development activities. As a result of this, during the second half of the 80s, the third generation of PE was produced and called PE 100. Laboratory tests showed that PE 100 had better performance and was safer than the first and second generation of PE raw materials.

The greatest advantage of PE 100 is that it has h igh stress resistance and a high safety coefficient. For example, the allowed operating pressure of pipe made of PE 80 according to SDR 11 is 10 bars while the ope rating pressure of pipe made of PE 100 raw material is 16 bars. This means that pipes made of PE 100 can operate at higher pressure with much lower wall thickness. The quality of products made of PE 100 have higher product quality and they also ensure up to 30% saving on materials .

3. ADVANTAGES AND DISADVANTAGES of PE

3.1. Advantages of the PE Technique

-Lightness
-Flexibility
-Long length (without coupling)
-Laid fast and economically
-Easily maintained
-No corrosion

A B C

Figure 5 (A) Procedure of throttle in PE pipes (B) Can be carried in coiled form (C) Corroded steel infrastructure pipe

3.2. Disadvantages of the PE technique

-Sensitive to storage (sensitive to ultraviolet rays)
-Sensitive to heat
-Its expansion is important
-Weak under cracking stress
-Flammatory
-Slightly higher temperature of fusion

3.3. Stability (Break) Pressure

Pipes laid under the ground are subjected to loads other than that of soil. These are added loads that exist such as the load of ground water even if the pipes are laid under the ground in laying pipes under the sea. Apart from these, there are added loads that are created on suction pipes that are operated with reduced pressure or on filling concrete used to fill the space between nested pipes .

4. TECHNIQUES FOR CONNECTION THROUGH WELDING

-Electro -fusion welding method, as seen in figure 6
-Butt-fusion welding method as seen in figure 7
-Extruder welding method ,

-Friction Welding method ,

This article studies the method of electro -fusion welding which is widely used in lines with or without pressure.

Figure 6 . Electro - fusion Welding Method

Figure 7. Butt-welding method

4.1. ELECTRO-FUSION WELDING METHOD

Electro -fusion method is a system that welds pipes together through fittings whose internal surfaces are covered with special resistance wires (figure 8). Welding is p erformed through melting plastic material with heating coils that reach a high temperature as a result of the stress applied to the sockets on fittings by an electro -fusion machine.(figure 9)

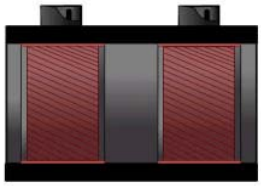

Figure 8 . Sleeve couplings and resistance wires

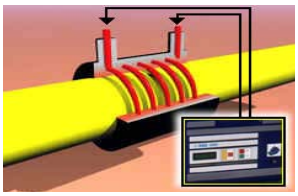

Figure 9 . Heating coils at a high temperature melting the PE pipe

The heat that's emitted as a result of the charge of electric energy on metal resistance wires inside the fittings is spread onto a wide surface, which melts the material. The winding number of wires and resistance values are determined based on the amount of energy that is needed for the material to melt. This energ y is created as a function of the stress to be applied to the wires and the duration of this stress.
As a result, fittings should be used in compliance with producers' data during electro-fusion welding procedures and welding machines that minimize staff e rrors (figure 10).

Figure 10. EF Welding Machine

4.1.1. FITTINGS USED IN ELECTROFUSION WELDING METHOD

Sleeve Coupling: The fitting that is used to connect two PE pipes with the same diameter
Reduction: The fitting that is used to connect PE pipes with d ifferent diameters
T: The fitting that is used to branch from a PE pipe
Saddle T: The fitting that is used to carry out smaller branching from a PE pipe
Ell (90° or 45°) The fitting that is used to change the direction of pipe run.
Cap: The fi tting that is used to cap a PE pipe at the end of a line.
Valve: The fitting that is installed in between t wo PE pipes to intervene in gas flow from above the ground. [4]

Figure 11 . Sleeve coupling and caps in different diameters

4.2. PREPARATIONS PRIOR TO ELECTRO -FUSION WELDING

The materials that will be welded should have the same parametric value. In addition to this, welding zone should be kept clean and the weather and surrounding conditions should be su itable (wind, dust, humidity, oil, etc.).

4.3. APPLICATION OF ELECTROFUSION WELDING PROCEDURE

●Before starting the welding procedure, it should be made sure that the pipe opening has a straight angle with respect to its own axis. If the angle is not straight, the pipe should be cut with guillotine (as seen in figure 12) to make it straight.

Figure 12 . Guillotine

●Ends of pipes to be welded should be placed up into the abutment point and the entrance limit should be marked on the pipe (figure 13).

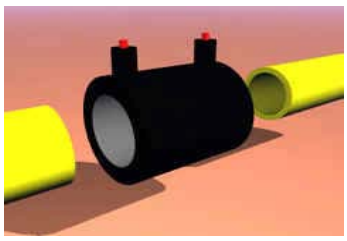

Figure 13 . Marking

●The surface on which welding will be carried out should be cleaned and surface oxidation should be wiped off using a scraper. Scraping depth is between 0,1-0,7 mm depending on oxide layer and dirt. The pipe whose surface has been scraped should never be touched and it should be protected from dirt y and unsuitable weather conditions. (figure 14).

Figure 1 4. Scraping

●The fittings that will be welded should be unpackaged during the welding procedure. Electro- fusion surfaces to be welded should be cleaned with industrial alcohol as seen in figure 15 and the surfaces of the pipe and the fitting that will be welded should not be handled after being cleaned.

Figure 15 . Cleaning Procedure

●The fitting that will be welded is placed up into the abutment point of the pipe (figure 16)

Figure 16 . Installation

●Pipe is fitted into electro -fusion sleeve coupling and the sleeve coupling is checked to see if it is in the same axis with the pipe. If necessary, it is clamped and then its horizontal inspection is done together with the pipe after making sure that the electro-fusion welding ends are on top and lastly it is positioned. (figure 17)

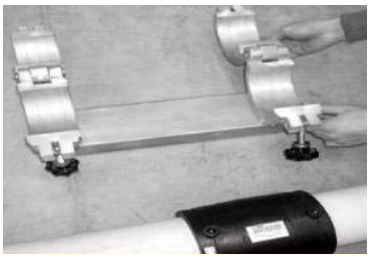

Figure 17 . Positioner

●Welding machine sockets are fitted into the welding ends of the fitting and ma de ready for welding. (figure 18)

Figure 18 . Sleeve coupling ready for welding

●After giving the machine is ready signal, the barcode on the sleeve coupling is read by the barcode-reader a nd manual welding parameters are entered as seen in figure 19 after which the welding procedure is started.

Figure 19. Reading the barcode

●In general, welding machines display the welding duration and v oltage on their monitor and end the welding procedure automatically. And after the cooling stage is complete, the clamps are dismantled. (figure 20) [5]

Figure 20 . Dismantling the equipment after the cooling time passes .

4.3.1. Main Principles of the Procedure

-Pipes of the same material can be welded through electro -fusionwelding.
-Solution flow rate fo r HDPE electrofusion welding is 0.3.…1.7gr/10dk. (190° C/5 kgj).

-Solution flow rates of pipes and sleeve coupling should be within the range given above. -Only the
pipes with the same solution flow rate can be welded.
-The area where welding procedures will be carried out should be protected from the effects of unsuitable weather conditions including snow, rain, wind, very strong sunbeams etc..
-The temperature of the welding zone should be between -5° C and +35° C .
-As a general rule, there should be barcode-readers on electro -fusion welding machines and
barcodes that show the welding parameters on electro-fusion fittings.
-Even though welding parameters can be conveyed through the barcode to the machine, the parameters that are written on the fitting can also be entered manually to the welding machine. Welding can be carried out this way too.
-The fixed position of the welded parts should not be changed before these parts are cooled down.

4.3.2. Pressure Test

Pressure test should be started after at least an hour when pipes are completely cooled. This test is carried out according to DIN 4279/1. On welded pipes, 1.5xPN pressure is applied. If no decrease occurs in this pressure value for 10 minutes, the test is finished successfully .[3]

4.4. ADVANTAGES OF ELECTRO-FUSION WELDING TECHNIQUE

-No maintenance needed after building the network
-No need for staff with specialized skills or very good hand -skills
-Low operation costs due to the convenience of welding that can be done after laying pipes of long
-length all at once.
-No need for cathodic protection.
-Quick ins tallation with the help of economical equipments
-Increased safety of network thanks to the quality of connection points and long -life materials
-Suitability of the use of PE pipes and fitting types without having to consider the differences of producers.[5]

Figure 21 . Laying pipes in trenches easily

4.5. REASONS O F ELECTRO-FUSION WELDING ERRORS

-Openings of PE pipes that were not cut with a straight angle
-Lack of scraping or poor scraping
-Lack of cleanliness in the welding zone
-Failing to straighten pipes prior to welding, use of crooked or oval pipes
-Not using a positioner
-Erroneous use of positioner
-Humidity in sleeve coupling or pipe
-Presence of dirt (sand etc) during connection
-Poor fitting
-Erroneous barcode reading
-Wrong welding parameters
-Welding immediately after cutting off the current
-Dismantling the positioner before the cooling stage is complete
-Using expired fittings
-Using misplaced fittings or fittings with severed resistance wire
-Marking error
-Too high o r too low ambient temperature
-Drilling for branching before the cooling stage is complete (poor drilling, risk of failed welding)
-Failing to protect welding parts from unsuitable weather conditions during welding and cooling
-Failing to follow the presc ribed welding procedure

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