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Doctoral Dissertation Analysis Report

***„Manufacturing process diagnostics and damage assessment of HSLA steel butt-welded pipelines"*,**
developed by Massimiliano Pedot
Silesian University of Technology, Department of Fundamentals of Machinery design

The undersigned, Nedelcu Dumitru, professor at "Gheorghe Asachi" Technical University of Iasi, Department of Machine Manufacturing Technology, I was appointed by the Resolution of the Mechanical Engineering Discipline Council of the Silesian University of Technology no. 104/2022 (30.11.2022) as an external reviewer for the analysis and support of the doctoral dissertation with the title "Manufacturing process diagnostics and damage assessment of HSLA steel butt-welded pipelines", developed by Mr. engineer Massimiliano Pedot under the exceptional supervisor of Professor Anna Timofiejczuk. Following the analysis of the doctoral dissertation content, I reached the following assessments and conclusions.

1. The importance and opportunity of the research

a. Timeliness of the topic

The welding plates and pipes together requires the weld to be done over the whole thickness of the part because of the assembly's mechanical continuity. Therefore a bevel is compulsory on the end surfaces of the parts to be assembled prior to welding them together. Due to the limitation of access to the inner face of the welded joint, the welding operation must be done from the outside, which is the reason why the edges must be properly prepared. The bevel geometry is given by different standards such as ASME, ISO, EN.

From the point of view of bevel, the important aspects are those related to beveling, facing and inside counterboring. The angle created by the bevel is important because it gives the welder access to the whole thickness of the pipe wall and allows him to make a uniform weld, and at the base of the groove a root pass must be made, after which the angle of the groove formed by the two bevels is filled by successive passes, in long or short layers. Facing consists in creating a flat surface at the end of the pipe, and the correct implementation of this operation

facilitates both the alignment of the pipes before welding and a constant opening of the root between the parts. The alignment of the pipes and the constant opening of the root are the parameters for the formation a correct weld puddle and the root pass has completely penetrated the joint. Another particularly important aspect is the tolerance of the pipes, which can lead to the different pipe thickness, a fact that could means to the different thickness of the root face at the time of beveling. The counterboring operation is thus recommended and consists of a light processing of the inner surface of the pipe in order to obtain a constant width of the root on the entire pipe circumference. The counterboring is especially important in automatic welding processes because the welding equipment cannot evaluate and compensate for shape errors, but it can be done in manual welding processes.

There are different types of the bevels according to the range of thickness. If the thickness is lower than 3mm the beveling on the end of the pipe is unnecessary and, in case of arc-welding process the penetrating of the whole depth of the pipe is possible in a single pass.The next thickness range is between 3mm and 20mm and the bevel must be made and the root can be filled by one or more passes. The next range belongs to the higher value compared with 20mm and are used bevels that enable the whole volume of the bevel to be reduced. In this case can be used double angle V joint and single and double angle J joints.

Concerning the machine tools there are different types such as axial movement machines and radial movement machines.

Pipelines welding is a current research topic because of its large-scale use in different industrial fields.

b. The structure of thesis dissertation

The doctoral dissertation developed by the Mr. engineer Massimiliano Pedot is very well designed and structured in 8 chapters and a series of 3 annexes. All the chapters have a logical development reaching the initially objectives established in the experimental research. The Introduction chapter, in addition to some general aspects, presents the purpose of the research, the description of the experimental plan and the welding technologies used. The second chapter presents the petrochemical plants layout follwed by welding processes and diagnostic methods used inside of third chapter. In a correct order follows a chapter wich highlights references to the method of samples manufacturing (bevels) for welding, taking into account both situations, sample with imperfections and sample with accepted quality level. The quality analysis of the pipe welded joints is carried out in chapter 5, and the destructive control tests carried out are presented in chapter 6. The online monitoring of the welding process, which can provide a lot of useful information in order to optimize the process, is carried out in chapter 7. The conclusions are pertinent and fully reflects the results obtained in the doctoral dissertation. The attached annexes reflect the large volume of experimental tests carried out as part of the doctoral dissertation.

2. Analytical considerations

Chapter 1 entitled *Introduction* the chapter generally presents aspects regarding the use of welded pipes in petrochemicals and refineries industries. Also, the main parts of a specific transport installation are presented, such as storage tanks, elbows, pipe fittings, pumps, heat exchanges and valves. It is important to highlight that all of these elements are connected through but-welded joints most of its. Highlighting that HSLA steels is the most used material, the author specifies that in the field of welding, experimental research is developed as there are many authors who deal with this subject and due to the need to get an appropriate quality of welded pipes, thus preventing explosions or other unwanted damages. The purpose of the doctoral dissertation consists in contributions regarding the welding of two HSLA pipes with different thicknesses. In the case of butt-welded joints, the problem of material deposition discontinuity or geometry arises and can be a major weakness to the system integrity. Also, the material discontinuity can be a reason of interactions between three different interfaces, such as: base material, HAZ and electrode material. The author carry on with the next scope focus on microstructure assessment and mechanical properties. Going further the doctoral dissertation presents the research steps focus on study of the manufacturing process of butt-welded joints, assessment of the influence of imperfections on the mechanical behaviour of the piping structure and joints, behaviour of the real scale pipes under the impact load forces and detection methods of defects of piping structure. I appreciate the diagram proposed by the author for obtaining the initially established objectives from figure 10. Also, the information in figure 10 clarifies the experimental part used using three welding processes (GMA, MMA, SSA), obtaining two welded samples in a horizontal position and two samples in a vertical position. Among the two welded samples, it is highlight that one sample had an imperfection in the root pass and one in the filler or cap pass.

The second chapter entitled *Petrochemical plants layout*, presents main elements of a petrochemical plant with description of storage tanks, piping systems, connectors and joints. The chapter also contains an overview of typical configurations of petrochemical plants. important for experimental research being the piping system configuration and detailed pipe segments. Towards the end of the chapter, the proposed case study directs the research to the type of pipe used API-5L X80 with 323.9mm as a diameter and 10mm as a wall thickness.

Welding processes and diagnostic methods as a general presentation are inside of third chapter with emphasis on the non-destructive control method that will be used.

Butt-welded joint pipe samples preparation is presented in fourth chapter up to the used welding technologies, GMA, MMA and SSA. The circumference of the welded pipe was divided into 8 segments and for each technology four samples were obtained for the study of root, filler and cap passes with vetical and horizontal welding position and six welding layers. For each technology used the WPS are presented and the welding parameters are correctly calculated. After the analysis performed on the previously presented samples, the authors

moves to the presentation of the welded samples with the corresponding quality level for each individual technology used with the analysis of the metallographic structure.

An important and specific chapter for pipe welded joints is the assessment of imperfections or defects, if the imperfections are classified as defects. The imperfections are studied in the case of the optimal classified samples for each technology separately, i.e. two samples of each technology. In the idea of identifying the imperfections, X-Ray tests were used, and the main imperfections were identified as cluster porosity, lack of penetration in the case of GMA3 pipe sample and more imperfections in the case of the GMA2 pipe sample. A similar volume of imperfections was also detected in the case of the MMA1 pipe sample.

Destructive test of the pipe samples is presented in chapter 6 with two main parts consists in destructive test of imperfections welded joints and impact tests only for optimal quality pipe samples. It is important that between the finite element simulation of the impact test and the results of the actual tests there is agreement, highlighting the location of the maximum stresses that can appear including the possible area of the first crack.

The monitoring of the pipe welding process is carried out in chapter 7 with the help of an infrared camera recording the temperature and welding current and arc voltage. The comments done are as an initially chosen welding segments function.

3. Assessments and conclusions

The scientific level of the doctoral dissertation developed by Eng. Massimiliano Pedot is a high one demonstrated by the original results obtained. I believe that this scientific level corresponds to the requirements of a doctoral thesis, the basis of this statement is the aspects previously presented in detail.

a. The thesis presentation

-The clear presentation of the methods and techniques used, the writing of the chapters, the elaboration of the graphic material are of a high standard, which demonstrates the real researcher qualities of the author;

-The doctoral dissertation structure is very well directed in order to fulfill the initially established objectives;

-The doctoral dissertation elaborated by Mr. Eng. Massimiliano Pedot has a favorable relationship between the written and the graphic part, between the analysis and synthesis part of the current stage of the research and its originality part;

-Mr. Eng. Massimiliano Pedot demonstrates a very good theoretical training, manifested in the way of designing and following the research program, as well as the ability to analyze and synthesize both the studied articles and of their own research.

b. Author contributions

Thus, I consider the following as main original contributions of the author:

-carrying out a bibliographic study regarding the structure of a production plant in the field of petrochemicals that uses welded pipes and the centralization of the research results found in the technical literature;

-assessment of the influence of imperfections on the behaviour of pipe welded joints using GMA, MMA and SSA welding technologies, identifying the following imperfections: lack of penetration, porosity, undercut, root concavity, incomplete filler groove and worm holes;

-obtaining the temperature variation diagrams according to the 8 welding sectors chosen from the circumference of welded pipes;

-the analysis model using finite element method of pipes welding;

-analysis of mechanical properties regarding tensile and compression resistance of welded pipes;

-obtaining the 3D models for compression tests.

Based on the comments and appreciations made above, I appreciate that the doctoral dissertation developed by Mr. Eng. Massimiliano Pedot has both high scientific and applied level, for which a significant amount of work has been submitted in the analysis and synthesis of the specialized references and for the realization of own research. The doctoral dissertation has many original contributions, corresponds to the requirements that are imposed on such a work and I propose the thesis defend.

Questions:

1). As we already know there are different types of the bevels according to the pipe wall thickness.

What are the thickness ranges and what comments can be made from the point of view of bevels and welding technology used?

2). The analysis of the mechanical properties is particularly important in the case of welded pipes considering their functioning in different industrial fields.

Which is the similarity between the theoretical model for the impact test and the experimental part achieved?

Iaşi, December 22, 2022

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