

## Review of the Doctoral Dissertation

of. Massimiliano Pedot, M.Sc. Eng.

**Title: „MANUFACTURING PROCESS DIAGNOSTICS AND DAMAGE ASSESSMENT OF HSLA STEEL BUTTWELDED PIPELINES”**

The basis for the review of the doctoral dissertation submitted by Massimiliano Pedot, M.Sc. Eng. titled "Manufacturing Process Diagnostics and Damage Assessment of HSLA Steel Buttwelded Pipelines" was a letter from the Chairwoman of the Council of the Discipline of Mechanical Engineering of Silesian University of Technology prof. Ewa Majchrzak, D.Sc, Ph.D, Eng. dated 02/12/2022.

### 1. Introduction

The catastrophic failure events of large-scale extensive building structures observed in the last decade have contributed to a change in design philosophy. This is particularly true of long-span, slender structures with few concentrated supports. Such structures are vulnerable to unforeseen events, and their disasters have severe consequences, usually disproportionate to the cause of the accident. Construction disasters due to human error and natural forces are on the rise. Terrorism and war conflicts have emerged. Human errors in the area of design and construction have always occurred, but their degree and extent have usually been within the acceptable range covered by the safety factors used.

Disruptive events, extreme loads, and unforeseen defects, which are not accounted for in design standards and regulations, pose a serious problem. The consequence of this is a widespread desire to use structures that are resilient to unforeseen phenomena. Therefore, resilience is becoming an absolute requirement. It is defined as the property of a structural system that enables it to survive in extreme and unusual situations. Since the concept of resilience changes a lot with context, it is therefore difficult to codify, e.g. modern design regulations require that the extent of damage to a structure be proportional to the cause. But so far the interpretation of resilience has not been fully agreed upon, which would facilitate its quantification and the development of detailed requirements.

The events of the past year related to the war in Ukraine and the energy crisis which developed in its aftermath show how important the problems of sustainability of pipeline systems are. In particular, their resilience to phenomena in which they were not designed to

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operate. The most sensitive parts of an extensive piping system are the connections of its components and angular elements. Technologies for making connections and monitoring their quality is the subject of many research studies.

The author of the dissertation has addressed the issue of testing butt-welded pipe connections in the context of the quality of the weld. Taking into account the cited information, in my opinion, the choice of the dissertation topic by the PhD candidate has contemporary and modern aspect and it is justified from a practical and economic point of view.

## **2. General description of the thesis**

The reviewed dissertation of Massimiliano Pedot contains 112 pages divided into eight chapters. The dissertation concludes with appendices including a description of the welding technology, descriptions of defects found in the samples and the results of destructive tests. A bibliography of 73 items of literature is included, including numerous online sources of documents contained on websites used in the preparation of the dissertation. The literature list includes 1 paper by the dissertation author. The dissertation contains 127 figures and 47 tables.

The thesis begins with Chapter 1 which defines structural resilience. Then, the author justifies his choice of the topic, analyzes the global energy demand and presents the types of pipeline connections (butt, flanged). Next section of the chapter presents a literature review of the analyzed topic and the author cites a description of the research plan. Chapter 2 includes a description of large petrochemical plants, types of storage tanks, pipelines and pipe connection systems. It concludes with references to literature sources. A description of welding methods, their advantages and disadvantages, and methods of diagnosing welded fields by non-destructive methods such as radiography, ultrasound, eddy currents, magnetic powder inspection, liquid penetration, thermography can be found in Chapter 3. Chapter 4 states what size pipe and material was used in the research work, justifying the choice. The rest of the chapter describes the preparation of pipe samples butt-welded in different ways. Joints were made with three welding technologies, with a variant of vertical and horizontal welding, introducing disturbances in some of them. The joints thus obtained were tested by non-destructive methods, and the results are included in Chapter 5. Chapter 6 presents the results of testing the prepared samples by destructive methods, performing tensile and three-point bending tests. Chapter 7 is an exploration of how the measured welding parameters, in this case temperature, current and voltage, affect the occurrence of welding defects in the test samples. The last Chapter 8 presents the conclusions of the research work carried out.

### 3. Research results and their evaluation

The dissertation deals with the study of welded joints of high-strength steel pipes used in petrochemical and industrial plants. The author applies the concept of resilience in the study, aiming to minimize the risks and consequences resulting from Natech type failures.

The dissertation analyzes buttwelded joints using three technologies. The choice of this type of connection was justified by the fact that the welding process is carried out not only under controlled conditions, but also directly at the installation site, where there are varying weather conditions or different contamination types. These factors can be the source of the formation of various imperfections inside the welded joint, which may affect the final quality of the joint. Therefore, the research plan conducted consisted of the following activities:

- Evaluation of the impact of impurities and weld imperfections on the quality of welded joints
- Evaluation of the quality of joints made on a real scale under catastrophic loads
- Determination of a useful method for detecting imperfections inside welds

The author of the dissertation devoted much attention to the manufacture of joints using hybrid welding technology consisting in the first stage of laser welding and then of GMA welding. The selection of parameters for laser welding technology was carried out.

In the research work, on the basis of radiographic examination of the entire length of the weld seam, an attempt was made to correlate the defect present with the cause of its formation. Surface defects, porosity, contamination in the form of water, oil or the effect of changing the welding parameter of shielding gas flow rate were analyzed. These studies were useful in determining how defects of different severity and different source of origin affect the load-bearing limit state of the joint.

Another important result of the research work is the demonstration that the best diagnostic tool for the quality of the analyzed joints is the thermal inspection performed during welding. A thermal imaging camera was used to conduct it. The depth of fusion resulting from the measurement of the temperature of the weld pool was related to the present defects. In addition, the author found that arc voltage and welding current can also provide information on the development of weld incompatibility.

The last part of the research work deals with the behavior of a buttwelded joint in an impact load test. The author states that the simulated conditions in the form of impact with a forging hammer weighing three tons, with a free fall from two different heights correspond to extreme conditions caused by catastrophic events, e.g. earthquakes, explosions etc. The research work then evaluates the condition of the joint and the presence of any cracks. Interestingly, the author reports that the welded pipe joint under study, even with complete flattening and cracking of the outer weld layer, maintains the overall integrity of the joint.

The research work concludes that the use of the hybrid method of welding X80 high-strength steel pipes is the best choice for the construction of petrochemical and industrial installations due to the strength of the joint and resilience to extreme loads.

## General comments

1. The author gives information about artificially introduced defects. There is no information on how they were introduced, at what length of the weld, etc. The question remains as to how the introduced disturbances affect the changes in parameters that were later correlated with the occurrence of defects. On what basis was the water contamination chosen, why was it not contaminated with sand, etc.? To what extent does the introduced contamination occur in reality, in the natural environment?
2. The author used only one graph each of welding voltage and welding current, whereas there is no comparison of values at the time of the occurrence of defects. What about the other welding parameters, such as the speed of the TCP during robot welding? In moments of reconfiguration, the speed of the TCP is not maintained at the programmed level. Why were the parameters of voltage and current, or the missing speed parameter not correlated with the present defects?
3. Such an approach, in the complex process of finding defects on the basis of a single parameter, is a major simplification. In the vast majority of cases, it is combinations of parameters that are responsible for the occurrence of defects.
4. Literature review on the subject of correlation of welding process defects with parameter values is insufficient.
5. I question the sense of using literature item 59, <https://konstrukcje.mz.pl/contact>. This is a website with company contact details.

## Specific comments

- Chapters and subchapters end with a figure and this is editorially incorrect. That applies to: p.13, p.19, p.26, p.28, p.34, p.46, p.47, p.49, p.50, p.52, p.54, p.55, p.56, p.57, p.58, p.64, p.68, p.70, p.72, p.74, p.77, p.79, p.80, p.87, p.91, p.96, p.98.
- Incorrect placement of page numbering
- Descriptions on drawings differ in font and size - e.g. pp. 32, 33, 34.
- In the description reference to parameters "Set of parameters number 15" (p. 64, line 4), there are no such parameters in tables 27-30.
- -Chapters and subchapters should contain an introduction, main part, summary. Here there is a division into subsections of 3, 4 lines of text, e.g. subsection 6.1.3 contains 3 lines of text.
- Bibliography is formatted incorrectly, e.g., para. 1 does not include the publisher and year of publication,
- Internet sources 24, 61, 69 refer to an official website of, for example, a company or an institute. However, the reader does not get to the page with the data that the author refers to in the thesis.
- literature item no. 40 cannot be determined.
- illegible drawings: Fig. 13, 22, 24,

#### 4. The summary and final conclusions

In the materials submitted for evaluation, the author presented the results of his research work on butt-welded pipelines. He adopted a research plan and carried it out. He stated as a conclusion that butt-welded joints used to connect two separate sections of pipes, in the case of extreme loads (such as explosions or earthquakes) to preserve the integrity of structures such as pipelines should be made of X80 high-strength steel, and the welded joint should be made by a hybrid method.

I believe that the reviewed dissertation of Massimiliano Pedot, meets the requirements for doctoral dissertations within the meaning of the Law on Higher Education and Science (Journal of Laws of 2018, item.1669), the Law of March 14, 2003 on Scientific Degrees and Academic Title and Degrees and Title in the Field of Art (consolidated text of Journal of Laws of 2016, item 882 with amendment: Journal of Laws of 2016, item 1311) and the Regulation of the Minister of Science and Higher Education of September 26, 2016 on the detailed procedure and conditions for conducting activities in doctoral dissertation proceedings, in habilitation proceedings and in proceedings for the conferment of the title of professor (Journal of Laws of 2016, item 1586) and may be admitted to further proceedings.

*Burghardt A.*