

Welding in the Context of Industrial Development

Emilia Florina Binchiciu ^{1*}, Victor Geanta ², Ioan Binchiciu ³, Florin Catalin Tabacu ⁴

¹ SC SUDOTIM AS SRL, 300222, M Viteazu no.30, Timișoara, Romania, sudotim@gmail.com

² National University of Science and Technology POLITEHNICA Bucharest, Materials Science and Engineering Faculty, 060042, Splaiul Independenței 313, Bucharest, Romania

³ SC SUDOTIM AS SRL, 300222, M Viteazu no.30, Timișoara, Romania

⁴ SC LITE CORPORATION SRL, 300079, E. Ungureanu no.17, Timișoara, Romania

Abstract. Welding is a complex process governed by a multitude of factors. Additive manufacturing and Industry 4.0 or 5.0 require the acquisition of specific knowledge related to closed-loop welding processes, supported by highly qualified personnel. The shortage of specialized personnel within the EU is being addressed through the launch of innovative research projects in support of multidisciplinary and multinational consortia. Through consensus, these consortia develop curricula, courses, and evaluation criteria. These materials are disseminated to those interested in specializing as trainers of specialists or process operators, through platforms that are easy to access and use for self-training and for obtaining certificates that confirm the knowledge acquired. These self-training methods are accompanied by the creation of regional centers of excellence and by the launch of innovative ideas for practical implementation, including the creation of start-ups based on the knowledge acquired.

1. Introduction

Welding as a process for making permanent joints was introduced into the repair and manufacturing processes of structures required by the market at the beginning of the 20th century, in Europe and the USA [1,2] due to its net advantages over riveted joints, successfully contributing to the US efforts in World War II by significantly reducing the production cycle of Liberty ships.

During the Cold War, it developed in two directions depending on the interests expressed by the warring camps.

In the USA and its allied countries, welding was oriented towards the creation of structures applicable in the leading industries of aeronautics, energy production and automotive construction through the research and implementation in industrial practice of welding processes with wire and shielding gases of aluminum, stainless steels, super alloys, etc. or/and thin laminates under pressure in points or lines. In the socialist camp states, the development of welding was done for the creation of heavy machinery, which mainly favored the research and implementation in production of mechanized welding under flux layer, or in slag bath.

Current EU directives guide the development of welding through robotic and automated processes specific to production type 4.0 and/or 5.0 [3].

Studies conducted by IIW on the skilled workforce for the fields of the future have highlighted a major shortage of personnel, which has necessitated measures to be taken regarding the education and training of highly qualified personnel with high capabilities in supervising and managing the loop welding processes of structures made of various alloys and/or super alloys. This aim is achieved through the Erasmus Plus program and projects appropriate to the intended purpose of training highly qualified personnel and mentoring them and those involved in welding[4].

2. Knowledge to be acquired

To understand and master the complex processes of making permanent joints through welding, academic-level knowledge in the following disciplines is required:

- welding engineering of circular materials, basics of welding processes, AI-assisted welding;
- circular and advanced materials engineering, including welding filler materials;
- engineering of phenomena adjacent to welding processes;
- robotic welding engineering and/or loop welding in automated cells;
- advanced knowledge of AI algorithms regarding the implementation of innovative ideas in the form of start-ups;
- knowledge of the patenting processes of innovative ideas and their implementation in products created in start-ups;

Acquiring the knowledge necessary to implement industries 4.0 and/or 5.0 can be achieved through individual or team training on

specialized platforms in the field of welding, carried out within the Erasmus Plus program funded by the EU.

3. Structure of the knowledge training process.

The team of authors is involved in two types of projects: one dedicated to innovative learning through digital courses, dual schooling and case studies, structured on learning modules and knowledge test grids [4] with the possibility of mentoring and consulting at regional entities of excellence [4] logically followed by the second type of course with dissemination of knowledge of innovative practices and their implementation in industries 4.0 and 5.0 through the establishment of startups[4].

4. Future prospects

The near future perspective is to promote systemic change and integrate circularity in the development and demonstration of new solutions for digitalized welding manufacturing of socially responsible products that will ensure the transition to a sustainable economy. The future trajectory of advanced welding technologies will be shaped by the continuous integration of intelligent systems for the innovative development of specific welding manufacturing processes for large-scale and/or mass-produced products with high potential for reuse through repeated repairs and long service lives, under harsh operating conditions. In this sense, advanced welding technologies will be shaped by the continuous integration of artificial intelligence (AI) in the innovative development of new advanced processes and materials. AI and machine learning are about to revolutionize the welding industry by enabling predictive maintenance, real-time defect detection and adaptive parameter adjustment. AI algorithms have the ability to analyze vast data sets from past welding processes, allowing them to optimize future operations, predict results, and define benchmarks with remarkable accuracy.

Progress from manual welding, governed by many uncertainties generated by the human presence in the process, to automatic and/or robotic welding involves a set of best practice measures in human-machine collaboration.

The distant future perspective, driven by the need to combine new, diverse, intelligent and sophisticated materials, is a fundamental change in the welding process with self-optimization and reduced dependence on human intervention, leading to greater consistency of welding quality, minimizing material waste and maximizing production.

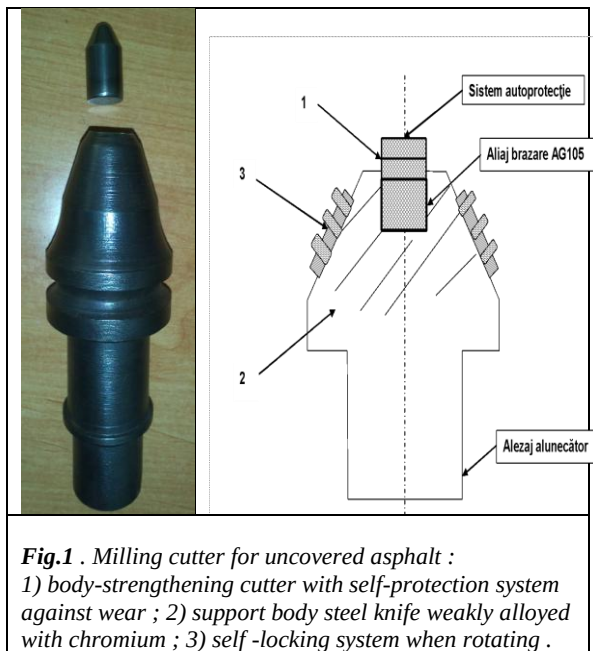
5. Case studies

To illustrate the above, two application examples are presented.

5.1 Asphalt stripping cutter [5]

The milling cutters for asphalt stripping are designed from the design phase for an extended lifespan, generated by a multiple cycle of reuse of the support by equipping it with an intelligent

self-locking protection system when rotating, consisting of a metallic deposit rich in angular tungsten carbides deposited by TIG welding and a tungsten carbide cutting body brazed into the support, figure 1, according to patent RO129863B1, figure 1.



After wear, the knife body is reused by equipping it with the previously mentioned protection systems.

5.2 Pressure and resistance spot welding electrode .

Resistance and pressure welding in spots or lines is a general utility process for thin-thick laminate joints.

The electrode, the active part of the welding process, figure 2, is made of copper alloys whose stock market price has increased dramatically in recent times, which is why the issue of reducing the cost price by assimilating new electrodes or a new process has arisen.



Fig.2 Electrodes for pressure and resistance spot welding

A car manufacturer turned to the robotic laser spot welding process, which required large investments in implementation and long payback periods.

The authors of the paper opted for the creation of a new, cheaper material with possibilities of industrial scaling. To this end, the operating conditions of resistance and spot welding electrodes and the innovative idea of a composite material were presented to AI, which was asked to develop a new material. The solution given by AI was experimented and optimized based on the criteria of the requirements of products with a long service life and reasonable cost.

Conclusions

Welding, a relatively new process, with application in mass production at the beginning of the Great War, has a major importance in the future due to the implementation of loop welding processes, AI-assisted and the requirements for sustainable development.

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