

## (A-II) SUMMARY

The entire activity carried out by me after defending the doctoral thesis and obtaining the doctorate in 2012 was related to the research, teaching and training activity. The habilitation thesis entitled "**Research on the development of welding and brazing and their influence on quality, safety and sustainable development**", developed by me at the Polytechnic University of Bucharest, includes two parts: the first part includes scientific and professional results. obtaining the title of doctor, and the second part refers to the future evolution of the career both in the scientific activity and in the academic one.

### (B-I) PROFESSIONAL AND ACADEMIC SCIENTIFIC ACHIEVEMENTS

The scientific research was carried out by me at the Polytechnic University of Bucharest (UPB) between 2012-2019, as chief of works and later as an associate professor. The research directions followed by me were grouped in three chapters that make up the habilitation thesis, as follows: C1-Contributions on welding of metallic materials; C2-Contributions regarding brazing and C3-Contributions regarding environmental pollution issues. These directions were approached taking into account several factors: continuing doctoral research on the fatigue of welded structures, my specialization as an engineer in the field of welding equipment and technology, collaborations I had with colleagues in the department, university and other universities, as well as the collaborations with the private environment that materialized in the realization of some research projects.

The researches included in this habilitation thesis are structured in two directions:

#### **Direction 1 Research in the field of welding and brazing**

##### **CHAPTER 1-INTEGRITY OF WELDED JOINTS**

Research starts from the influence that welding has on the concentration of stress and lifespan to fatigue. Calculation formulas are presented, tested experimentally for the calculation of stress concentrators in the case of fillet and cruciform welded joints and it is shown that in the case of non-removable joints required for fatigue, welding has an unfavorable effect compared to other assembly procedures, in the sense that high stress concentrators are introduced by welding. We can state based on the research undertaken that the existence of a welding bead on a part or machine part, exerts an unfavorable influence on the number of cycles until failure in the case of variable requests, in the sense of decreasing this number, by up to 40% in which the part or machine part does not have a welding bead. Considering that welding introduces high stress concentrators, but it is an indispensable process of non-removable assembly and that there is almost no industrial sector where this process is not met, the problem is to reduce the concentration of stresses. It starts with the presentation of the results of the investigation of the level of stresses in the cruciform-welded joints, with the help of the finite element method, depending on several geometries of the welding seams. We then continue with the brief presentation of the results obtained in the case of research project P3, regarding the application of the two techniques of rehabilitation of cruciform welded joints "Grinding weld toe" and "WIG remelting weld toe" technique on cross welded joints, both in the case of static stresses as well as in the case of variable stresses in which the phenomenon of fatigue appears in time.

The efficiency of applying these two rehabilitation techniques is found only in the case of variable demands, in which case there is a significant increase in fatigue life. In the case of static stresses, the application of rehabilitation techniques does not bring significant advantages over failures caused by static destructive tests. but even so we can only speak at a theoretical level of unlimited fatigue life for certain stresses, as seen on the Wohler curve, below will be presented an innovative technique of welding and rehabilitation "Temper Bead Welding -TBW ", to try to solve this shortcoming. This technique consists in the deposition of additional welding cords with controlled linear energy, following the obtaining of a fine granulation at the level of microstructure and of a low level of tensions. As a result of the application of the above-mentioned technique, there was a 30 percent increase in fatigue life and a reduction in microhardness in the areas of thermomechanical influence of the welds. A final issue addressed in this chapter is the issue of hydrogen diffusible in welding. The results of the influence of the chemical composition of the coated electrodes on their moisture content and the amount of diffusible hydrogen in the cord are presented, noting that the electrodes with the lowest moisture absorption are those with 60% sodium silicate and 40% potassium silicate. Regarding the influence of diffusible hydrogen in the cord on its mechanical characteristics and plasticity and toughness, after research we concluded that diffusible hydrogen decreases the characteristics of plasticity and toughness and does not practically influence the mechanical characteristics when breaking by static traction.

## **CHAPTER 2-INTEGRITY OF BRAZED JOINTS**

Brazing is another non-removable assembly process by hard soldering, even having a number of advantages over welding. Therefore, naturally I also introduced brazing in my research directions. In this section are presented several results of research on brazing, as follows. A first research performed is related to the preparation of components for brazing by ultrasonic cleaning. The aluminum oxide that is present on the surface of the parts made of aluminum alloys represents on the one hand a protective layer against the action of the environment, but on the other hand it makes brazing difficult. The large differences between the melting point of aluminum and that of aluminum oxides lead to the appearance of defects in the brazed joint, unless a proper preparation is made in which the initial layer of oxide formed is removed. The aim of this research is to improve the preparation of the surfaces to be assembled by adjusting the ultrasonic tanning parameters and to find an optimal method. The new surface preparation technology consists of ultrasonic cleaning of aluminum parts and degreasing them with dimethyl ketone or propanone solution (C<sub>3</sub>H<sub>6</sub>O). This simple technology allows the rapid implementation of the surface preparation process in industries that use 6061 aluminum alloys taking into account the very low degree of pollution. In this way, conventional surface preparation technologies, such as Aloclene 100 baths or deoxidation solutions, can be successfully replaced. Based on the results obtained from destructive tests and non-destructive examinations but penetrating and ultrasonic immersion liquids, it was concluded that the surface cleaning technology for 6061 aluminum alloys must be the following: ultrasonic cleaning of surfaces (Device power 100%; heating temperature 550C, sample holding time in the tank 20 minutes, ultrasonic cleaning solution EM 404 in 25% concentration and degreasing with dimethyl ketone solution of the surfaces. The use of 6061 general purpose aluminum alloy cleaning technology is non-toxic to the operator and the EM-404 cleaning solution is biodegradable and is more than 90% dissipated. Regarding the Influence of preparation in view of brazing on the hardness of the joint, experimental data are presented on how the surface

preparation influences the hardness of reconditioned aluminum alloy assemblies by brazing. The areas of the basic materials, the filler material, as well as the areas of thermal diffusion resulting from the brazing operation will be studied. The main problem is the difference in hardness between the materials to be assembled and the material with which they are assembled. This can be a major cause, which can cause defects during operation by reducing the strength of the assembly. By choosing an optimal surface preparation technology, we can reduce these differences by obtaining an assembly with uniform properties throughout its structure, so with a longer lifespan. It is found based on the results obtained that the optimal preparation technology in terms of hardness is the one called in the thesis TP III AL with the following stages: pickling in Almeco 100; degreasing of surfaces with acetone; alkaline chemical degreasing (soda) 30min; hot water bath; cold water bath washing; pickling in ALOCLENE 100 12min; hot water washing in the bathroom; cold water bath washing; clarification in nitric acid 5min; hot water washing in the bathroom; cold water bath washing; hot air drying. Another issue addressed in this section is related to the reconditioning of aluminum alloys using new filler materials. In this research, a new additive material called Durafix was highlighted, used in the brazing technology of 6061 aluminum components, which has several advantages: emissions of pollutants into the atmosphere in much smaller quantities; the use of brazing technology without a preparation of the surfaces to be put in contact so expensive from a financial point of view; the preparation technology specific to the new filler materials is not limited by the dimensions of the parts; net energy efficiency superior to oxyacetylene welding which involves a much lower cost of consumables due to the low temperature at which it takes place. It is recommended as a surface preparation technology to be brazed with Durafix electrodes a mechanical cleaning with a stainless steel wire brush before surface heating, but also during heating. Thus, the oxides that form are removed. Following the detachment attempts (exfoliation) and the metallographic analyzes performed, an optimal brazing technology was reached using Durafix electrodes which consists in their deposition in the first phase, on both surfaces of the base material, following that after solidification, the parts are placed in contact and be heated to the melting point of the filler material, after which being brought into contact with each other, a smooth structure is obtained without defects. Also in this section, other research was undertaken regarding the crack testing of brazed joints. The aim of the research is to identify an optimal technological solution for brazing aluminum alloys, using test specimens subjected to detachment tests. In order to obtain conclusive results, tests are performed on two different sets of specimens ("bent specimens" brazed end to end with the bending of the edges to a length of 5 mm, respecting the technology: pickling in Alocene 100 solution, deposition of the additive material on both sides of the base material, the use of spectral acetylene and the use of a neutral flame and "experimental specimens"), obtaining two sets of data that we will compare. These tests, which are called detachment tests, are part of the series of tests standardized by ASME regulations. They are used to determine where the crack occurs in either the base material or the filler material. Thus, we can determine whether the crack is cohesive or adhesive. Based on the obtained results, the following conclusions can be drawn: in the case of "bent specimens" as well as in the case of "experimental specimens" the rupture takes place in the basic material and not in the brazed cord; in the case of both sets of specimens the dispersion of the obtained results validates the experiments; the technology consisting in pickling in Alocene 100 solution, the deposition of the additive material on both sides of the base material, the use of spectral acetylene

and neutral flame can be considered optimal, because after the detachment (exfoliation) tests it was found that we obtain a maximum resistance in the brazed cord. Research undertaken in the field of fatigue stress of brazed joints, consisted of experimental tests for variable stresses of some specimens, after which with the help of mathematical statistics software, based on experimental results, were obtained certain regression functions that describe the curves. durability and which bring a number of advantages: starting from a relatively small number of experimental data, with regression functions, we can generate a very large number of values with an estimated error that tends to zero; computer systems simplify the experimental design and can simulate real-time behavior of the structure; the reduction of the number of specimens ultimately determines the reduction of the expenses for materials, labor and the additional times of preparation of the specimens.

### ***Direction 2 Contributions on improving performance in organizations***

#### **CHAPTER 3-CONTRIBUTIONS IN THE FIELD OF QUALITY AND PROCESSES**

The concept of quality has evolved over the years, due to the development of the industrial and information society. Over time, quality evolves from quality control, to quality assurance and then to total quality, taking into account both the social component (staff involvement, participation) and the economic component (the image of the organization, reducing quality costs). The first part of this chapter presents the research we have undertaken on quality. Several aspects related to quality are addressed depending on the publications to which we have contributed to a greater or lesser extent. For a start, we approached the issue of quality improvement using Ishikawa diagrams and the Pareto method. The Pareto diagram helps interventions to streamline management through action plans built around the main causes of problems, by providing a strong visual orientation in decision making. It is a tool for qualitative analysis, as it focuses on process parameters in terms of frequency. The defined parameters can be events, errors, characteristics, etc. Then, we approached the issue of increasing the performance of an organization, using the KANBAN method. The Kanban method is based on the principle of taking over tasks by team members as they become available (pull system), and not on placing tasks without being requested by the person to perform them (push system). We have shown that using the Kanban method the components are manufactured only when they are needed, so the production of extra components is eliminated. As there is no extra production, cutting waste and scrap are reduced. Following is the presentation of research on the elimination of losses using LEAN manufacturing techniques and KAISEN philosophy. LEAN manufacturing is today one of the most successful production strategies to improve competitiveness. To be successful, it is necessary to adopt a healthy production system, based on solid concepts and philosophies. Thus it was decided to adopt and accelerate the development of the concept "LEAN MANUFACTURING". The KAIZEN method or "CONTINUOUS IMPROVEMENT THROUGH THE INVOLVEMENT OF EVERYONE" is a teamwork methodology used to systematically solve problems and apply improvement solutions.

#### **CHAPTER 4-CONTRIBUTIONS IN THE FIELD OF OCCUPATIONAL SECURITY**

In this chapter we have presented some elements related to occupational safety research. It begins with the presentation of research on the evaluation of

organizational stress in the cutting laboratory of the Polytechnic University of Bucharest, Department of Quality Engineering and Industrial Technologies. Manufacturing techniques offer solutions for many industries, especially the automotive and technology industries. In technical universities, students must research the equipment related to manufacturing. In the industrial hall, environmental factors such as noise, temperature, cold, dust, affect students and teachers. The aim of this research is to establish occupational stress under external factors that affect the health of employees and their ability to stay focused. The experimental part consists of a proposed questionnaire that was completed based on environmental disturbances, a comparative analysis between the responses of 160 students and 20 teachers and a proposal plan for improving working and study conditions and to reduce stress at work. It then continues with a series of research on the galvanic response to skin stress in the case of psychologists and engineers. Given that stress is invasive and has a negative impact on health for all social and occupational categories, affecting even psychologists and IT engineers, it has become a serious problem that requires much investigation to find the best way to reduce it. The purpose of this research is to investigate stress in the psychological and engineering fields. In order to achieve the set objectives, a questionnaire on stress at work was applied to the participants. Subsequently, the participants were measured for the galvanic response of the skin, making a comparison between the stress levels in both environments. Following the results obtained, some recommendations could be made to reduce the level of stress at work.

## **CHAPTER 5-CONTRIBUTIONS REGARDING THE QUALITY AND SUSTAINABLE DEVELOPMENT OF THE ENVIRONMENT**

Given that the environment in which we live is bombarded with waste from all sectors such as industry (semi-manufacturing and manufacturing technologies in the mechanical field), oil processing, medical, pharmaceutical, food and others, the problem of pollution becomes a pressing and should we are concerned with all those who work in the field of research, on the one hand to quantify the impact of different processes and technologies on the environment and on the other hand to find solutions for improvement. In close connection with the above, I considered it natural and natural that in my research should appear elements related to the quality and sustainable development of the environment. Through the collaborations I had with various partners from the university and from the private environment and based on the research carried out, I had the opportunity to investigate a little this vast field of pollution issues. The research undertaken and the results presented in this section have addressed both industrial pollution and that caused by medical waste. Thus, in the first phase, the results of research related to environmental pollution in the case of casting non-ferrous metal alloys are presented, the research consists in analyzing the gases released during casting during casting parts in the casting laboratory within the department where I work as a teacher. Then it continues in the same register with the determination of the environmental impact of the reconditioning technologies by electric arc welding with coated electrodes and in protective gas environments as well as of the two rehabilitation technologies "Grinding weld toe" and "WIG remelting weld toe". , using an experimental stand built for measurements and an improved algorithm for calculating pollution coefficients. Naturally, further research is presented on the impact it has on the environment (air and soil), the process of oil processing in the Dobrogea area. Being monitored the oil processing activity in the period 2013-2017, when Romania had already joined the EU, the research showed that both the

air and the soil in the area of influence of the oil processing company were not polluted with specific chemicals. I know that medical waste is a substantial component with a negative impact on the environment, that it has a particularly high degree of danger and that their amount is constantly growing both in Romania and worldwide with the development and implementation of the use of instruments. disposable, I considered it appropriate to address this issue in my research. In this part are also presented the researches regarding the mechanical design and its impact on the environment, of a thoracic drainage device, completely reusable in optimal conditions of sterilization and safety for patients and medical staff. The completely reusable thoracic drainage system presented in this research, has as main advantage the deep ecological character due to the minimization of the disposable material necessary for each patient and the reuse in full safety of a large part of the system after decontamination and reesterilization in optimal conditions. Also in this section will be presented a research method based on "opinion polling", the results of which were published in an ISI paper in the yellow zone. The method uses a questionnaire with 23 items, addressed to doctors because despite the restrictive legislation of the European Union regarding the storage and destruction of hospital waste, it is not always respected. Each study participant works in a different hospital, so the sample surveyed is representative.

### (BII) CAREER EVOLUTION AND DEVELOPMENT PLANS

#### **CHAPTER 6 DEVELOPMENT OF THE SCIENTIFIC, PROFESSIONAL AND ACADEMIC PLAN**

This section is dedicated to future plans in academic and research activity. Taking into account the scientific activity carried out so far, my future concerns will be aimed at two research directions, as follows:

##### **a. Research in the field of welding and brazing**

- Numerical methods with which welded structures can be successfully investigated
- Obtaining welded joints with a long fatigue life
- Development of special electrodes for welding
- Research on obtaining the concave geometry of the cord, with the help of machining
- Research on the design of special devices attached to welding guns
- Investigation of stresses in welded parts
- Alternative non-removable assembly technologies for aluminum alloys
- Polymer-aluminum composite materials by gluing using two-component adhesives

##### **b. Contributions on improving performance in organizations**

- Elimination of losses in organizations using modern manufacturing techniques
- Contributions in the field of occupational security
- The impact of industrial processes on the environment

### (BIII) BIBLIOGRAPHICAL REFERENCES

This section contains 100 bibliographic references, most of them being elaborated by the candidate as sole author or within research collectives.

**Claudiu BABIS**

