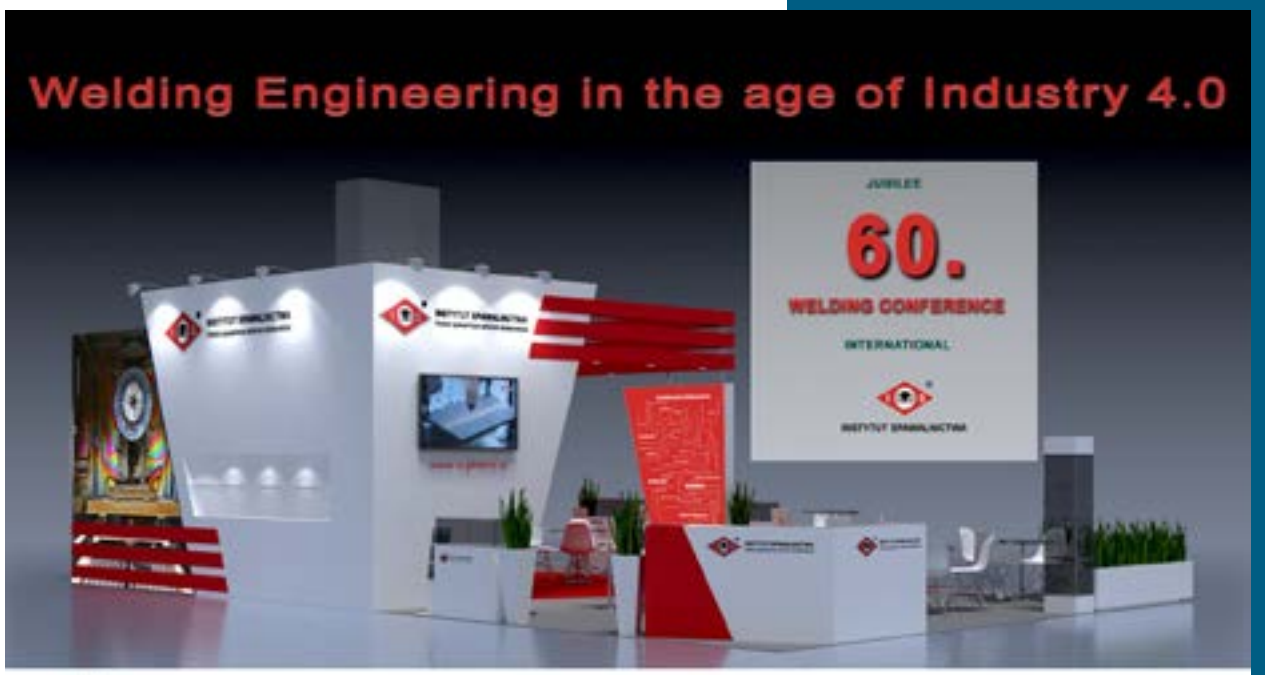
ISSN 2300-1674

BIULETYN
INSTYTUTU SPAWALNICTWA



No. 5/2018

INSTITUTE OF WELDING BULLETIN

BIULETYN

INSTYTUTU SPAWALNICTWA

No. 5 BIMONTHLY Volume 62

CONTENTS

INSTITUTE OF WELDING

The International Institute of Welding and The European Federation for Welding, Joining and Cutting member

Biuletyn Instytutu Spawalnictwa
ISSN 2300-1674

Publisher:
Instytut Spawalnictwa (The Institute of Welding)

Editor-in-chief: ***Prof. Jan Pilarczyk***

Managing editor: *Alojzy Kajzerek*
Language editor: *R. Scott Henderson*

Address:
ul. Bł. Czesława 16-18, 44-100 Gliwice, Poland
tel: +48 32 335 82 01(02); fax: +48 32 231 46 52
biuletyn@is.gliwice.pl;
Alojzy.Kajzerek@is.gliwice.pl;
Marek.Dragan@is.gliwice.pl
http://bulletin.is.gliwice.pl/

Summaries of the articles

R. Ferraz, I. Fernandes, M. Sibisteanu, L. Quintino, C. Eady – The Importance of An Integrated Quality Assurance System in Professional Qualification Development and Implementation

DOI: 10.17729/ebis.2018.5/1

The increasing pace of technological changes in manufacturing is reducing the useful life of formal qualifications. High level monolithic qualifications require large amounts of effort to review and revise them, especially in an international context. The fourth industrial revolution is pushing traditional education systems to their limits and shedding light on their shortcomings. Ensuring that the future workforce is qualified for the challenges of Industry 4.0 involves addressing several aspects. Employers and their employees demand highly relevant pre-employment education, delivering both the fundamental engineering knowledge and addressing the latest materials and processes. The EWF education and qualification approach aims to provide the right qualification at the right time. Its success is derived from a robust and industry-focused quality system, with wide stakeholder involvement from welding research institutes, educational organisations, certification bodies, companies, trainers and trainees. The cooperative approach of EWF members and stakeholders delivers harmonized quality assurance that has ensured the reliability and credibility of the international qualifications so that they have become trusted by employers. This paper aims to present how international qualifications support the implementation and exploitation of new technologies, enabling innovation in manufacturing. Furthermore, it presents the importance of an integrated quality assurance system in the development and implementation of professional profiles that support mobility and progression in employment.

M. St. Węglowski – Industry 4.0 vs Welding Engineering

DOI: 10.17729/ebis.2018.5/2

The notion of Industry 4.0 poses a new challenge for various industries, including the widely defined welding engineering. Presently, we are witnessing the Fourth Industrial Revolution initiated in 2010. This revolution will significantly influence not only mass production of goods but our daily life as well. Many solutions related to the new industrial revolution will affect our reality in the years to come. To face these new challenges, welding engineering personnel will need to collaborate in interdisciplinary teams on a much closer basis to implement fusion welding, pressure welding and adhesive bonding technologies in industrial practice. Producers of welding equipment are already offering solutions constituting inherent elements of Industry 4.0. Only time will show the developmental direction of welding engineering. The study presents ideas behind individual industrial revolutions, the historical outline concerning the development of welding technologies, requirements which should be satisfied by personnel implementing and benefiting from Industry 4.0 as well as exemplary welding engineering-related solutions.

S. Keitel, U. Mückenheim, U. Wolski, S. Lotz, J. Müglitz, T. Sigmund – Robotic Welding on Tube Nodes

DOI: 10.17729/ebis.2018.5/3

Hollow-profile structures are significantly more stable than structures made using open profiles, which is the main reason for their use in truss and truss-like structures. The node inter-sections of such structures require three-dimensional curved welded joints. Small and medium-sized enterprises usually weld tubular frame and truss structures manually, which is highly time-consuming and cost-intensive. In

addition, this method requires personnel with corresponding qualifications to carry out the work as the welders need to adapt to constantly changing conditions in weld preparation and welding positions, which obviously requires intensive training. Replacing this manual activity with mechanised welding processes would provide great relief to welders.

Z. Mirski, T. Wojdat, P. Kustroń, W. Dreko, L. Mroczkowski, D. Lądyszkowska – Robotic CMT arc braze welding of 10CrMo9-10 steel tubes with internal copper lining

DOI: *10.17729/ebis.2018.5/4*

The article presents issues related to arc braze welding of tubes made of 10CrMo9-10 (10H2M) boiler steel lined inside with copper. In addition, the study points to possibilities of producing joints using conventional and innovative welding methods as well as presents results of radiographic, metallographic and mechanical tests (static tensile test, technological bending test, hardness measurements) of braze welded joints made using a robotic braze welding stand and the CMT (Cold Metal Transfer) method.

D. Golański, T. Chmielewski, B. Skowrońska, D. Rochalski – Advanced Applications of Microplasma Welding

DOI: *10.17729/ebis.2018.5/5*

The article discusses microplasma arc applications in welding, surfacing and remelting processes, describes the effect of microplasma arc and its burning conditions as well as presents the properties and the application range of plasma welding. In addition, the article presents examples of microplasma welded joints of thin elements and discusses the application of microplasma arc in surfacing and remelting as well as indicates advantageous features of plasma arc and its application potential as an alternative to other welding power sources.

E. Turyk, M. Łomozik – Multiple MAG Repair Welding of Steel S1100QL with the Removal of Defective Fragments of Welds Using Mechanical Treatment

DOI: *10.17729/ebis.2018.5/6*

The research discussed in the article involved the performance of tests assessing the effect of a one-time and four-time repair welding thermal cycle on mechanical properties of 18 mm thick butt joints made of toughened steel S1100QL. The tests also involved the determination of mechanical properties of a production joint and joints subjected to mechanical treatment-based repair, involving the use of the MAG method (138) and metallic flux-cored wire STEIN-MEGAFIL 1100 M. It was ascertained that the mechanical properties of the joints subjected to mechanical treatment-based repair were similar to those of the joints subjected to repair welding involving the removal of a defective part using arc-air gouging.

D. Toncelli, S. Craciun, B. Leduey – Welding consumables with lower emission of Cr^{VI}

DOI: *10.17729/ebis.2018.5/7*

The article provides information about new filler metals used in the welding of popular stainless steel grades and discusses the formation of Cr^{6+} in dusts as well as alkaline metals connected with the process. Newly developed covered electrodes and flux-cored wires are characterised by the reduced emission of dust during welding and by the lower content of carcinogenic hexavalent chromium in dust. One of the major difficulties, i.e. the obtainment of required properties of the electrode cover, was solved by using a two-layer cover. New grades of electrodes and flux-cored wires were subjected to tests, among others at the British TWI, to compare the emission of dust and that of Cr^{6+} with those generated by standard materials. The above-named tests revealed that the at-the-source emission of Cr^{6+} was 4 times lower

in terms of the electrodes and 3 times lower as regards the flux-cored wires than emissions accompanying the use of standard materials.

T. Brtník, I. Mika, J. Dolejš – HFMI Method-Based Increase in Fatigue Service Life of Welds in High-Strength Steels

DOI: *10.17729/ebis.2018.5/8*

Until recently, the fatigue service life of welded joints exposed to medium and high-cycle fatigue has been a factor restraining the wider use of high-strength steels. Recent research on increasing the fatigue service life of welded joints (weld) has revealed that the aforesaid strength can be significantly increased using the high frequency mechanical impact (HFMI) method. Independently performed tests demonstrated that an increase in fatigue service life was proportional to the strength of the base material subjected to the aforesaid method. The HFMI method involves the application of compressive stress at the critical point of the interface between the weld and the base material. The method is an advanced variant of methods developed in the Soviet Union in the 1970s, used to increase the fatigue service life of welded joints in submarine structures. The method can be applied both in relation to butt and fillet welds. The article summarizes the current state of the art concerning the practical usability of the HFMI method in relation to conventional steels (characterised by lower mechanical properties) and high-strength steels. An important factor affecting increasingly high popularity of the HFMI method is that fact that the method has been included in IIW's recommendations concerning fatigue-related structural calculations.

S. G. Hryhorenko, V. Ju. Belous – Effect of Electron Beam Welding and Heat Treatment on the Structure and Properties of Technical Titanium with an Alloying Dope of Boron

DOI: *10.17729/ebis.2018.5/9*

The study discussed in the article included the analysis of features characterising the formation of an electron beam-welded joint made of a titanium alloy (Ti–TiB). The study also involved the investigation of the effect of heat treatment on structural-phase transformations in the weld metal and in the heat affected zone. The heat treatment of the welded joints resulted in the decomposition of the metastable phase, the distribution of boron particles in the structure as well as the increase in the structural homogeneity, leading to the improvement of mechanical properties.

L.N. Orlov, A.A. Holyakevych, I.I.Alekseenko – Hardening Surfacing with Flux-Cored Wire Increasing the Service Life of Rotating Discs of Defiberiser for Mineral Wool Production

DOI: *10.17729/ebis.2018.5/10*

The article discusses the MAG method-based surfacing of discs of a mineral wool defiberiser performed using self-shielded arc and submerged arc. In addition, the article presents results of tests concerning the service life of discs in relation to the chemical composition of the surfaced layer.

G. Posch, J. Bruckner, H. Ennsbrunner – Industry 4.0 in Welding Engineering

DOI: *10.17729/ebis.2018.5/11*

To reach the next developmental stage of welding technologies, i.e. the implementation of the Industry 4.0 concept and the Internet of Things (IOT) in welding, it is crucial to understand and provide the welding responsible for technological development with necessary data; the objective being the facilitated obtainment of necessary machine data in future. The foregoing necessitates the development and adaptation of modern welding equipment to needs of the smart factory as well as to collect and evaluate a considerable amount of data relevant to

welding processes. This paper presents a short overview of already available possibilities and ideas enabling the adaptation of today's solutions to the needs of Industry 4.0. in future.

D. Miara, J. Matusiak – Effect of Welding Conditions on the Structure and Properties of Joints Made of Wrought Aluminium Alloys in High--Speed FSW

DOI: *10.17729/ebis.2018.5/12*

The FSW process is primarily used to join elements made of similar materials. Generally, the making of structures involving the use of similar materials require low welding rates. The article presents research results connected with the high-speed FSW of wrought aluminium alloys and the effect of welding conditions on the structure and properties of joints. The welds made within the research-related tests were characterized by high quality and free from any imperfections.

M. Korzeniowski, A. Domińczuk, J. Jurenc, T. Piwowarczyk – The Use of Video Systems in the Automatic Evaluation of Electrode Consumption in a Robotic Spot Resistance Welding Station

DOI: *10.17729/ebis.2018.5/13*

The assessment of the consumption of electrodes used in resistance welding processes is an important issue significantly affecting the quality of welded joints. The article presents an individually developed station integrating an industrial robot, a video system, a columnar sharpener and a "Smart Light" lamp. The elements of the station, i.e. sensors and the video system were selected in view of their use in the lot production of welded structures. The developed and optimised system enables the automatic evaluation of the consumption of spot resistance welding attachments. In turn, tested and implemented decision-making algorithms enable the performance of welding processes with the permanent monitoring of the quality of the above-named attachments and the assessment of their further sharpening possibility during the production process.

J. Górka, K. Grzesica, K. Golda – Purity of Backing Gas and the Quality of TIG Orbitally Welded Joints in Stainless Austenitic Steels

DOI: *10.17729/ebis.2018.5/14*

The article discusses research involving tests aimed to identify the effect of the purity of backing gas on the quality of TIG orbitally welded joints in tubes made of stainless austenitic steel X5CrNi18-10 (1.4301) having dimensions of φ 50.8 × 1.5 mm, without the use of a filler metal. The research-related tests included the analysis of the chemical composition, the identification of the content of ferrite delta, non-destructive tests of welded joints (including visual tests involving the evaluation of temper colours on the face side and on the root side), radiographic tests, metallographic tests and destructive tests of welded joints. The metallurgical shield of the weld face was provided by the shielding gas (argon; purity class 5.0), the flow rate of which amounted to 8 dm3/min. Initially, the root of a weld was shielded by the backing gas (argon; purity class 5.0) and, afterwards, by mixtures of argon and air. The tests revealed that an increase in the content of residual oxygen in the backing gas mixture was accompanied by a change in the colour of oxide layers present in the HAZ area and in the weld root area. Because of the requirements contained in Danish report no. 94.34 by the FORCE Technology Institute and American Standard no. ASME BPE-2012, related to temper colours, only the joint containing 4 and 25 ppm of residual oxygen in the mixture of backing gases can be applied after previous purification and passivation.

D. Fydrych, A. Świerczyńska, G. Rogalski, J. Łabanowski – Application of Multivariate Analysis Methods in Welding Engineering

DOI: *10.17729/ebis.2018.5/15*

Phenomena and processes taking place during welding are usually very complex and, for this reason, should be described using multivariate methods. The article discusses the methodological basis and selected application areas as regards the solving of welding problems using statistical multivariate methods. In addition, the article presents exemplary applications of the design of experiment, multiple regression analysis, cluster analysis, principal component analysis and logistic regression analysis. The application of multivariate analyses provides the possibility of performing the mathematical description of joining processes, which, after verification, could be used to forecast results of such processes, particularly in relation to the properties and fatigue service life of welded structures.

J. Słania, M. Matuszewski – Digital radiography – Preparation of the System for Tests

DOI: *10.17729/ebis.2018.5/16*

Digital radiography is becoming increasingly popular in non-destructive tests of welded joints and castings, enabling the obtainment of a repeatable testing method and the minimisation of test time. However, the obtainment of proper test results requires the verification of quality levels (during tests of products) in accordance with a related standard concerning a given product or following the customer's specification. In terms of digital radiography, the process of preparation significantly affects test results. For this reason, the article discusses the calibration of a testing system, enabling the obtainment of enhanced detectability and the satisfaction of primary quality requirements.

K. Pańcikiewicz, L. Tuz, Z. Żurek – A New Look at the Classification of Cracks in Welded and Braze Welded Joints

DOI: *10.17729/ebis.2018.5/17*

The making of structures using advanced materials and joining technologies is frequently accompanied by limited weldability problems. The obtainability of joints characterised by required properties can be limited, among other things, by susceptibility to crack formation. The article presents an overview of classification of cracks in welded and braze welded joints based on reasons for crack formation and the period of crack development. The primary division of fabrication/production-related cracks includes hot, cold, lamellar and annealing cracks. The study recommends the extension of the above-presented classification by including cracks occurring at a temperature higher than ambient temperature and lower than the lower limit of high-temperature brittleness range. The above-named temperature range could include cracks triggered by the loss of plasticity in the solid state resulting from the occurrence of ductility-dip brittleness and cracks related to liquid metal embrittlement.

L. Tuz – Effect of Preheating on the Structure and Mechanical Properties of Steel S1300QL

DOI: *10.17729/ebis.2018.5/18*

The use of advanced structural materials entails the necessity of adapting typical welding processes to special requirements resulting from the limited weldability of new materials, often tied to their complex chemical composition or unique mechanical properties obtained in technological processes used in the production of steels and alloys. An example of steel characterised by limited weldability is steel having a guaranteed yield point of 1300 MPa, where such high strength is obtained by adding slight amounts of carbide-forming elements and using complex heat treatment processes. As

a result, not only a heat input accompanying the process of welding but also any additional procedures connected with the pre-weld preparation of edges or preheating could adversely affect the above-named properties. The tests described in the article involved the simulation of preheating combined with various cooling conditions. The tests enabled the identification of a permissible temperature, at which no unfavourable changes took place as well as the determination of critical temperatures, the exceeding of which could significantly alter mechanical properties.

J. Nowacki, A. Sajek – Verification of Properties of Joints Made of Advances High Strength Steels in the Conditions of the Complex Thermal Cycles of the HPAW Process

DOI: *10.17729/ebis.2018.5/19*

The article discusses the primary issue related to the verification of properties of joints made in AHSS in relation to conventional structural steels and based on the identification of cooling time t8/5. The solution suggested in the study involving the application of the Finite Element Method is based on two computational models. In addition the article presents a material model allowing for properties of single metallic phases and their interaction during the welding cycle. The study also describes the numerical model of the HPAW (plasma + MAG) heat source composed of two models predefined in the Simufact.Welding software programme corresponding to the nature of constituent processes. The research-related tests also involved welding simulations and experimental verification. The tests demonstrated the conformity of simulation results and the high usability of simulation when verifying properties of joints.

V. Kancharla, M. Mendes, M. Grupp, B. Baird – New Achievements in the Fibre Laser Welding Technology

DOI: *10.17729/ebis.2018.5/20*

Fibre lasers are innovative tools in the welder's hands. The continuous development of fibre lasers combined with newly developed welding techniques enable the performance of technological tasks extremely difficult or even impossible to carry out using conventional technological lasers and conventional welding techniques, e.g. the welding of precise elements made of copper, dissimilar materials, thin metal foils or the joining of imprecisely made or matched elements. The article presents the laser welding process involving the use of a dynamically inclined laser beam and discusses its advantages when welding copper, aluminium alloys and plastics. In addition, the article describes the technique of integrated process monitoring referred to as inline coherent imaging (ICI), enabling the improvement of welded joint quality.

M. Urbańczyk, S. Stano, M. Banasik, J. Adamiec – Effect of Hybrid Laser Arc Welding on the Structure and Properties of High Yield Point Steel S960QL

DOI: *10.17729/ebis.2018.5/21*

The article discusses the advantages of the hybrid laser + MAG welding method as well as the advantages and exemplary applications of high yield point steel S960QL. The study involved the performance of the hybrid welding of butt joints having various thicknesses and made of high yield point steel (960 MPa) in the flat and in the horizontal position. In addition, the study included macro and microscopic metallographic tests of the test joints.

J. Adamiec – Cracking of Welded Structures in Power Engineering Systems

DOI: *10.17729/ebis.2018.5/22*

An increase in demand for electric power necessitates the revamping and construction of systems characterised by increasingly high efficiency. The construction of power units

exposed to supercritical and ultra-supercritical parameters requires the use of new technologies and materials. The study presents two examples concerned with the cracking of boiler systems related to the use of a new hybrid welding technology and the use of a new material, i.e. Alloy 59. It was ascertained that the use of state-of-the-art technologies and materials is justified, yet requires the analysis and verification of designs assumptions and operating conditions.

J. Matusiak, J. Wyciślik-Sośnierz – Welding of zinc-coated steel plates versus emission of welding fumes to work environment

DOI: *10.17729/ebis.2018.5/23*

The article presents an investigation concerning assessment of the influence of technological parameters of metal arc welding of zinc-coated steel plates on welding fumes emission (CO, NOx). It has been designed correlation between welding method, type of protective coating, welding current parameters, type of filler metal and welding fumes emission. The research was performed for MAG, CMT, ColdArc oraz AC MIG Pulse welding of steel plates with different types of protective coatings. As a filler metal there has been used solid wire type G3Si1 with diameter of 1.2 mm and metal cored wire type T3T Z M M 1 H15 with a diameter of 1.2 mm.

P. Cegielski, D. Golański, P. Kołodziejczak, A. Kolasa, D. Rochalski, T. Sarnowski – Advanced Design and Verification of Tracks and Welding Positioners – External Axes of Robots

DOI: *10.17729/ebis.2018.5/24*

Multiaxial welding positioners and tracks intended for integration with an industrial robot as their external axes should be characterised by specific kinematic structure, the wide range of movements and high rigidity translating into previously assumed positioning repeatability. The above-named requirements are often contradictory to one another, therefore the development of a safe and functional structure requires the application of advanced design and verification methods. The pursuit of the accomplishment of the ultimate solution cannot be solely based on the design engineer's intuition or the lowest price criterion. One of the recognised methods of the verification of CAD models CAD involves the application of FEM-based strength analysis (Finite Element Method). The article presents the effect of research and development works related to the design and industrial implementation of new types of manipulators (external axes of robots) in PPU ZAP Robotyka, Ostrów Wielkopolski.