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CONTENTS

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Contents

Summaries of the articles

F. Nascimento, L. Quintino - Developments in Friction Stir based technologies

Solid state techniques have been widespread and have the potential to be introduced in several industries solving problems that are not possible to resolve through the more common technologies. Friction Stir Welding is a welding technique based on friction mechanisms that has been studied since its discovery on 1991. This technique can weld aluminium and copper alloys and is of particular interest for the energy sector. Friction stir technology is widely used for welding aluminium through its potential reaches other areas. The present paper covers examples of applications of friction stir welding, surfacing and channelling, with potential for industrial implementation. The present paper depicts one example application in the replacement of copper by aluminium in electric power transformers which is of particular interest due to the savings that can be reached. A feasibility study has been carried out in which it is demonstrated that this process can effectively weld thin aluminium and copper plates producing very good results in the material mechanical and electrical properties. It was also confirmed that this process can effectively weld aluminium to copper however some restrictions must be made to guarantee a sound weld. Surfacing techniques are of particular interest because they can improve the mechanical properties of a certain material making it more robust to the environmental conditions. Developments in friction stir processing and friction surfacing are shown and result in improvement of the mechanical properties compared to the base material. It was concluded that both these processes can be used as surfacing techniques and usually the processed area presents better mechanical, wear and corrosion properties than the substrate. Friction Stir Channelling is a novel technique that can have a widespread application in the mould industry as it is a suitable technique for the production of internal conformal channels. An example focusing the production of two prototypes for the mould industry with the objective of rapidly homogenizing the surrounding temperature is presented in this paper.

E. Meiss - Adhesive Bonding – Advantages and Limitations

Adhesive bonding is becoming increasingly important among industrially applied joining techniques. Growing demands for all kinds of products necessitate the development of new materials and material combinations. The ability of adhesives to join very different materials creates new application opportunities. In addition, the original properties of materials are usually maintained as, if compared with welding or brazing, adhesive bonding is a process poor in heat. The use of adhesive bonding makes it possible to eliminate other weaknesses accompanying, for instance riveting or screwing. In addition, this method enables the integration of real joint properties (sealing, vibration damping or anticorrosive protection) with a structural element. However, according to ISO 9000 adhesive bonding is a special process, which means that the quality of an adhesive bonded connection cannot be 100% verified by NDT methods. This fact entails the necessity of maintaining an appropriate quality management system in order to obtain and ensure high production quality.

S. Keitel, J. Neubert - Laser Welding – New Applications in Welding of Pipelines and Rail Vehicles

Laser welding and its combination with arc welding processes (laser-GMAW hybrid process) are obtaining an increasing importance

for industrial applications. This paper gives an overview about the latest results of the development to qualify the laser welding process for tube welding, pipeline girth welding and welding of rail vehicles. Laser technologies are now available for tube production as well as for pipeline welding. There are technical solutions for production of longitudinal and helical welded tubes. Laser technologies are also applicable for pipeline welding in preproduction and under field conditions. Different procedures have been developed depending on tube diameters and wall thicknesses. The article contains examples of applications in gas and oil transport as well as in water pipeline transport. Laser welding of rail vehicles includes technologies for bogies and car bodies. Dependent on the application laser welding was used as a single process or in combination with GMAW. In the case of laser welding in the production of rail vehicles a close tie with the construction is necessary. The examples used demonstrate that laser welding is a safe technology used in highly sophisticated applications.

J. Górka, S. Stano - Properties and Structure of Laser Beam Welded Joints of S700MC Thermomechanically Treated Steel

The article presents the structure and properties of joints welded using a laser beam without a filler metal, made of 10 mm thick thermomechanically treated high yield point S700MC steel. The related non-destructive tests have classified the joints described above as representing the quality level B in accordance with standard 13919-1. The destructive tests have revealed the joint characterised by the tensile strength approximately 5% higher than that of the parent metal. Laser welding without the filler metal increases the content of chemical elements responsible for steel hardening (Ti, Nb), which leads to a weld toughness decrease below the acceptable value of 27 J/cm^2.

J. Adamiec, M. Więcek - Technology for Laser Welding of Ribbed Pipes Made of Inconel 625 Nickel Alloy

The increasing demand for electric energy in Europe requires continuous search for new energy sources as well as structural and technological solutions. Maintaining the present level of electric energy production requires the modernisation of previously used objects and the construction of new units for supercritical and ultrasupercritical parameters. The increase in thermal efficiency with the simultaneous energy cost reduction is possible due to ribbed pipes used in heat exchangers. The article presents ribbed pipe manufacturing technologies with special attention paid to an innovative laser welding technology developed at Energoinstal S.A. The use of high-power disc lasers enables welding ribbed pipes made of nickel alloys such as, for instance, Inconel 625. Due to their heat resistance and high-temperature creep resistance laser welded ribbed pipes made of the Inconel 625 alloy are elements of heat exchanger characterised by high usability potential. The article presents the results of technological tests involving laser welding of ribbed pipes made of the Inconel 625 alloy conducted at Energoinstal S.A. It was ascertained that the technology developed meets related requirements and can be qualified according to PN EN 15614-11.

D. Rutkowski, A. Ambroziak - Effect of laser strengthening on the mechanical properties of car body steels presently used in automotive industry

The article describes advanced very high-strength steels having the DP-type ferritic-martensitic structure, steels having the TRIP-type ferritic-bainitic structure with retained austenite and hot stamping steels. The research was focused on the selective DY044 laser strengthening of DP600, TRIP700 and 22MnB5 steels. The tests involved the determination of strengthening curves for the parent metal and for the weld

as well as the determination of mechanical properties for DP600, TRIP700 and 22MnB5 steels strengthened by laser beam penetration, depending on the penetration depth. The research also involved the preparation and verification of parent metal and weld numerical models.

A. Ivarson - Joining of Advanced High Strength Steels

This paper describes joining of Advanced High Strength Steels (AHSS). Over the past 2 to 3 decades the usage of AHSS has increased constantly, and will continue. In order to succeed with the overall design it is of importance to know how to design AHSS from e.g. fatigue, bending and welding point of view. As presented in this paper, AHSS has to be treated differently than mild steel regarding welding.

L. Karlsson, L-E. Svensson, K. Hurtig - Influence of dilution on properties of high strength steel weld metals

Chemical compositions of high strength steels and welding consumables differ significantly and dilution can therefore affect weld metal properties. Effects of dilution were studied by welding steels with yield strengths of 777 MPa and 1193 MPa using several arc welding methods with the addition of welding filler materials with a strength >800 MPa. Butt welds were produced in 12 mm plates and weld metal cooling rates were documented. High quality welds were produced efficiently with all welding methods and dilution varied between 3% for manual metal arc welding to 73% for laser-hybrid welding. Weld metals were martensitic/bainitic with proportions of microstructural constituents depending on alloying content and cooling rate. Overmatching weld metal strength was achieved for all welds in Weldox 700, and strengths >1000 MPa were recorded for Weldox 1100. Fracture in transverse tensile testing was for both steels located in the base material or HAZ. Low dilution, rapid cooling and single pass welding contributed to higher strength. Impact toughness decreased with increasing strength and increasing dilution. In conclusion, many welding methods can be used successfully for welding of high strength steels but effects of dilution and cooling rate should be considered when optimising properties.

B. Rutzinger - Influence of the welding process to the dilution rate of weld overlays on unalloyed steel using the weld consumable ERNiCrMo-3 (Alloy 625)

Nickel based alloys are used in different applications of the industries like power generation or the petro chemical industry. Out of the variety of these protection methodologies, weld overlay with ERNiCrMo-3 (Alloy 625) has proven to be the most widely accepted. This paper describes weld overlays of ERNiCrMo-3 (Alloy 625) with the welding methods GMAW Pulse, CMT, Tandem, CMT Twin, TIG cold wire, TIG hot wire and Laser Hybrid. The investigation of these probes includes the Fe dilution of the base material, the distribution of the Fe concentration through the weld overlay, and further on the welding speed and weld deposition rate.

P. Bernasovsky - Examples of pipe failures in Slovak transmission gas pipelines

The paper deals with some case studies in Slovak high pressure gas pipelines. All cases were caused by an interaction effect of the weld anomalies excessive misalignment, poor workmanship or cold strain hardening, of the metallurgical aspects in pipe production liquid Cu embrittlement, irregular microstructure and by an additional bend loading earthquake, sudden pipe settlement and landslide or site bending.

J. Pilarczyk, M. St. Węglowski - Electron Beam Use in Welding and Allied Technologies

The article discusses the use of an electron beam in welding engineering, presents examples of

electron beam utilisation in industry taking into consideration welding, fast prototyping and surface texturisation, provides information on techniques which can be used during welding as well as indicates practical application areas and advantages of the technology.

O. Sherepenko, S. Jüttner, V. Zhuk - Resistance spot welding of ultra-high strength steels with production-related process influences

Ultra-high and advanced high strength steels find their application in the production of vehicles, for the manufacturing of car body components, especially of those that are crash safety relevant. Production related influences may affect the process stability and cause the loss of quality that can be particularly critical for spot welds with high quality requirements. Despite the high accuracy of the manufactured components, process related variations of geometry may cause gaps between the welding partners. For welding, these gaps must be bridged prior to turning on the welding current. During the welding process of such elements with gap, the preload results in specific thermal and mechanical loading of the joint that can cause imperfections in the welded joint, e.g. cracks. This article gives a review on hot stamping process as well as on previous investigations in RSW of AHSS and UHSS with production related gaps. The present study shows the influence of production related gaps on process stability, and changes in microstructure and geometry of spot welds with gaps. Based on experimental investigation, an effect of welding time, coating and production related gaps on the quality and mechanical performance of RS-welded joints is discussed.

B. E. Paton, L. M. Lobanov, V. V. Łysak, V. V. Knysz, V. I. Pavlovskij, V.P. Priluckij, A. N. Timoszenko, P. V. Gonczarov, Guan Cyao - Strain-free Welding of VT-20 (BT-20) Stringer Panels

The paper presents results of a complex of investigations on the development of technology of welding of stringer panels of titanium alloy using a slot weld, providing minimum residual stresses and strains and high values of their service life at cyclic loads. Welding of T-joints was performed by slot welds on full-scale specimens using three method of welding: electron beam, automatic non-consumable electrode argon arc welding along the layer of' activating flux and automatic non-consumable electrode argon arc welding with immersed arc. To eliminate the residual welding stresses and strains the preliminary elastic deforming of elements being welded was applied. Testing of all the types of specimens for their fatigue at longitudinal cyclic tension was carried out. The effect of heat-treatment, peening mechanical treatment and repair-welding technologies on their fatigue life was also determined. On the basis of results of investigations of full-scale specimens the batches of stringer panels of 1200 mm length were manufactured and tested. It was found that making of slot welds by argon arc non-consumable electrode welding along the activating flux using preliminary elastic deforming and high-frequency mechanical peening provides the higher characteristics of fatigue life of welded stringer panels of high-strength titanium alloy VT-20 as compared with electron beam welding and argon arc non-consumable electrode welding with immersed arc. The developed technology can serve the basis for industrial manufacture of welded stringer panels of high-strength titanium alloys.

W. Kuzniecow, K. Szapowałow - Effect of Nano-oxides on the Structure and Properties of Low-alloy Steel Weld Metal

The article presents the effect of nano-oxides on the distribution of non-metallic inclusions as well as on the weld metal structure during welding of low-alloy steels. It has been ascertained that providing the weld pool with a 0.5% vol. of aluminium and titanium nano-oxides leads to

the formation of acicular ferrite structure characterised by high mechanical properties.

M. Bieloev - Design, Production and Assembly of Large-Sized Structural Elements of Large Diameter Reservoir Roofs

The innovative method of constructing large-sized roofs (41 m in diameter) of oil reservoirs. The sizes of the individual sections of the umbrella-type roof structure were reduced by dividing them into two parts. As a result it was possible to increase the scope of shop production and facilitate transport and assembly, thus reducing total costs. Figures present joints made using shielded metal arc welding and self-shielded tubular-cored arc welding.

Z. Mirski, K. Banyś, Z. Fałek, T. Piwowarczyk - FEM-aided Design of Welded Pressure Vessels According to ASME BPVC Regulations

The article presents the historical background and a brief introduction to the American ASME BPVC regulations concerned with welded boilers, pressure vessels and nuclear facilities. The article presents a methodology for the design of two-shell tube welded pressure vessel (autoclave) based on ASME Sec. VIII Div. 1 regulations. Due to the lack of a computational method (calculation based on formulas) for the complete pressure vessel according to ASME Sec. VIII, Div. 1, related calculations were performed using a computational method according to ASME Sec. VIII, Div. 2 Part 5. The results of the calculations are presented in the form of tables, graphs and numerically generated visualisation.

A. Kiszka, T. Pfeifer - Effect of EN Ratio in Welding Current Waveform on the Properties of MIG/MAG Welded Joints Made of Various Structural Materials

The article presents the use of VP current for welding thin elements of various structural materials, describes the course of tests and discusses the test results related to the determination of the effect of EN ratio in the current and arc voltage waveforms on the weld geometry, penetration depth and welded joint quality.

T. Chmielewski, D. Golański - The Application of Kinetic Friction Energy for Ceramics Metallisation

The paper presents the problem of ceramics metallisation using the friction method based on the mechanism of joint formation, where the energy of kinetic friction is directly transformed into heat and supplied in specified amounts directly to the joint formed between the layer and the substrate. The paper also presents friction-utilising ceramic metallisation process developed by the authors as well as shows the results of microstructural examination of metallised layers obtained.

T. Pfeifer, J. Rykała - Welding EN AW 7075 Aluminium Alloy Sheets – Low-energy Versus Pulsed Current

The article presents test results related to welding thin EN AW 7075 aluminium alloy sheets and the course of technological tests aimed at determining the usability of the CMT and MIG-Pulse methods for welding 2.0 mm EN AW 70775 alloy butt joints. The article also discusses the basic difficulties encountered while welding the 7xxx series alloy and presents the specific character of the welding method employing low arc energy and using pulsed current. The article presents the selected results of strength-related and macroscopic metallographic tests of the welded joints along with their detailed analysis. The study also describes the "circle path" hot crack resistance test; the joints obtained in the test were subjected to detailed microscopic metallographic examination and microanalysis of chemical composition. It should be emphasised that the CMT method enables the obtainment of good quality and aesthetics of welded joints made of the aluminium alloy generally recognised as poorly weldable.

K. Pańcikiewicz, A. Ziewiec, P. Zbroja, P. Kajda, E. Tasak - Microstructure and Properties of Dissimilar Welded Joints Made of Steels used in the Power Industry

The article presents the microstructure and properties of dissimilar welded joints of pipes made of the 304HCu (X10CrNiCuNb18-9-3) and P92 (X10CrWMoVNb9-2) steels in the as welded state and after PWHT. The test-related TIG welding was carried out using two filler metals in the form of the Thermanit 304HCu and the EPRI P87 filler metal wires. The tests revealed the significant influence of heat treatment time extension on the decrease in the hardness of the martensitic steel and its HAZ as well as an on the increase in the hardness of the austenitic steel, its HAZ and of the weld made using the Thermanit 304HCu filler metal. The microscopic observations revealed the presence of a carburised zone on the fusion line between the P92 steel and the weld made using the Thermanit 304HCu filler metal wire.

A. Pietras, A. Węglowska, B. Rams, Sz. Kowieski, D. Miara, M. St. Węglowski - Friction Stir Welding of Copper Plates

The objective of the work was to develop a technology for the friction stir welding (FSW) of copper elements of thicknesses exceeding 15 mm and possible to use in the production of current conductor rails. The length of the conductor rail element joining line amounts to approximately 100 mm. The first stage involved FSP tests, i.e. tests of copper plasticisation, using the FSW method and creating the compact weld structure on plates having thicknesses between 8 and 20 mm. The next stage consisted in friction stir welding of copper elements. The investigation involved testing copper plasticisation conditions while using the FSW process, the development of a welding tool as well as the development of conditions for proper welding of sheets/plates having thicknesses of up to 20 mm. It was observed that properly formed welds require the use of a relatively low tool rotation rate and good cooling of element-fixing tooling.

J. Matusiak, P. Szłapa, J. Wyciślik, W. Marczak - Experimental Tests on the Effect of Gas-shielded Arc Welding Technological Conditions on Sound Level

During various welding processes workers are exposed to activities connected with audible and ultrasonic noise. In spite of the continuous development and improvement of production means, robotisation of welding works and the development of measures protecting workers against noise, the exposure to noise continues to be one of the major issues in welding engineering. The article presents experimental tests focused on the effect of gas-shielded metal arc welding technological conditions on the level of sounds generated during welding processes. The study discusses the results of tests performed for 7 selected gas-shielded arc welding methods, i.e. MAG, MAG Pulse, CMT (Cold Metal Transfer), ColdArc, RapidArc, MAG Double Pulse and AC Pulse. The test-related analysis was concerned with the correlations between welding material-technological conditions and the acoustic pressure level of sound A as well as the acoustic pressure level in the 1/3 octave bands of audible and ultrasonic noise spectrum.

T. Piwowarczyk, A. Małachowska, M. Winnicki - Numerical Modelling and Application Potential of the Cold Spray Method

The article presents the theoretical and practical aspects of the Cold Spray method numerical modelling,indicates the main numerical analysis research areas(particle speed modelling and particle deformation modelling),determines the major parameters considered during simulation, demonstrates analysis-based correlations as well as presents recommended software, modelling examples and their major

problems,modelling result verification methods and their practical usability. The article also evaluates the usability of numerical analyses by demonstrating the application potential of Cold Spray method.

M. Nowak, J. Buchowski, D. Wiśniewski - Off-line Programming of Welding Robots – Process and Economic Advantages

The article presents the advantages of the off-line programming of robotic welding stations using the example of DTPS (Desk Top Programming and Simulation System) software by Panasonic.

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D. Fydrych, G. Rogalski, J. Łabanowski - Problems of Underwater Welding of Higher-Strength Low Alloy Steels

The article characterizes the presently used techniques of underwater welding and the problems connected with obtaining the required properties of joints. The text also presents test results related to the weldability of higher-strength steels in underwater conditions and indicates the main R&D trends in welding technologies aimed at reducing the effect of inconvenient underwater welding conditions and improving the quality of joints made under water.

T. Chmielewski, K. Kudła, M. Węglowski - Analysis of the Effect of Arc Welding Characteristics in Modern MAG Welding Variants on Welding Properties and Weld Geometry

The article presents experimental tests aimed to compare welding conditions and technological properties of butt joint welding using low-energy gas-shielded metal arc welding variants such as MAG Standard, MAG Puls, TwinPuls, SpeedPuls, SpeedUp, SpeedArc, SpeedRoot and SpeedCold. The article also presents a comparison of welding efficiency of these processes and the effect of power source dynamic characteristics on the geometry and macrostructure of welds.

D. Majewski, A. Winiowski - Brazing Filler Metals of Limited-Noxiousness

The recent results of technological process and composition-related research performed at Instytut Spawalnictwa in Gliwice and dedicated to brazing filler metals and fluxes of limited noxiousness. The brazing properties of newly-developed low-melting cadmium-free silver filler metals in the form of flux-coated rods and low-fluoride fluxes. The quality and mechanical properties of joints brazed using the newly developed filler metals.


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