VII INTERNATIONAL CONFERENCE ON WELDING AND RELATED TECHNOLOGIES

WRT 2024

ABSTRACTS



7-10 October 2024 Yaremche, Ukraine

E.O. Paton Electric Welding Institute of the NAS of Ukraine International Association "Welding"

VII INTERNATIONAL CONFERENCE "WELDING AND RELATED TECHNOLOGIES"

Program and Abstracts of Papers 7–10 October, 2024, Yaremche, Ukraine

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98 abstracts of plenary and poster papers are presented, which highlight scientific achievements in the following directions of welding: automation of welding and related processes, strength, reliability and life of welded structures, nano-structured systems, surfacing, coating deposition, special electrometallurgy processes, materials, equipment and technologies for medicine, mathematical modeling of welding and related processes, technical diagnostics and non-destructive testing in recent years by scientists and specialists from Ukraine, Australia, Canada, China, Czech Republic, France, Germany, Israel, Italy, Mexico, Poland and USA.
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Dear colleagues, participants and guests of the VII International Conference "WELDING AND RELATED TECHNOLOGIES" 2024

On behalf of the E.O. Paton Electric Welding Institute of the National Academy of Sciences of Ukraine and the Conference Program Committee, I am pleased to welcome you all and extend my heartfelt congratulations on the opening of this significant scientific and technical forum. Our Conference is taking place at a very difficult time for Ukraine, which is associated with the full-scale military aggression of russia, and yet we managed to get together here in Ukraine, for which I want to thank all of you.

Welding and related processes serve as a pivotal force driving scientific and technological advancement not only within modern industrial production, but also across various other sectors, including transportation, construction, medicine, and increasingly, defense and security. Welding and allied technologies exert a profound influence on the global market, with irresistible evidence suggesting that this positive direction of qualitative growth will continue to expand.

Our Conference serves as an important platform for presenting the latest advancements in both theoretical and applied research within the field. It brings together a diverse group of scientists from academic institutions and universities, postdoctoral researchers, students, industry professionals and domain experts from across the globe. This forum is invaluable for fostering personal and professional connections, establishing creative collaboration among experts in welding and related processes, and setting priorities for future research and the practical application of technologies such as welding, surfacing, cutting, brazing, coating, special electrometallurgy, and more.

I extend my warmest wishes to all, participants and guests of the Conference. May you enjoy robust health, and may your creative endeavors continue to flourish with success and innovation.

Prof. Igor KRIVTSUN
Director of the E.O. Paton Electric Welding Institute
of the National Academy of Sciences of Ukraine,
Chairman of the International Conference
"Welding and Related Technologies 2024"

PROGRAM

VII International Conference "Welding and Related Technologies" 7–10 October 2024, Yaremche

Day I – 07 October 2024

10:00-18:00 19:00-22:00	Registration, meeting and accommodation of guests Welcome reception
	Day II – 08 October 2024
09:30-10:00 10:00-10:20 10:20-10:50	Registration, meeting and accommodation of guests Opening/Greetings to the conference participants Invited lecture
10:20-10:50 10:50-11:40	Oral session
11:40–12:00	Coffee-break
12:00-13:00	Oral session
13:00-14:00	Lunch
14:00-14:30	Invited lecture
14:30-15:40	Oral session
15:40-16:00	Coffee-break
16:00-17:20	Oral session
	Day III – 09 October 2024
09:30-10:00	Invited lecture
10:00-11:40	Oral session
11:40-12:00	Coffee-break
12:00-13:00	Oral session
13:00–14:00	Lunch
14:00–14:30	Invited lecture
14:30–15:40	Oral session
15:40–16:00	Coffee-break
16:00-17:20	Oral session
19:00-22:00	Conference dinner
	Day IV – 10 October 2024
09:30-10:00	Invited lecture
10:00-11:40	Oral session
11:40-12:00	Coffee-break
12:00-13:00	Oral session
13:00-14:00	Lunch
14:00-15:00	Poster/Oral sessions
15:00–15:20	Closing ceremony

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PLENARY AND POSTER PAPERS

STUDY OF THE EFFECT OF MANUFACTURING PARAMETERS ON THE MECHANICAL PROPERTIES OF THE LPBF-ALSI10MG ALLOY

Adzhamskyi S.V., Kononenko G.A., Podolskyi R.V.

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Additive manufacturing technology, also known as 3D printing, has been used more and more recently, and the number of materials and methods that can be used is expanding. The purpose of the study: Establishing rational modes of manufacturing samples from the LPBF-AlSi10Mg alloy with a layer thickness of 40 μ m, studying their influence on mechanical properties depending on the location on the construction platform. As a result of the conducted research, the dependence of the mechanical properties on the integrity of the sample and the location on the platform was established.

FINITE ELEMENT MODELLING OF THE INFLUENCE OF THE FILLER WIRE SPEED ON THE WELD FORMATION DURING THE NARROW GAP WELDING OF TITANIUM ALLOYS

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In narrow gap TIG welding, the speed at which filler wire is fed into the weld pool is a critical parameter. It can significantly influence the weld quality, including the melting of the side walls of the joint, which can led to a decrease heat input and reduced penetration into the side walls hence increasing the chances of such defects as lack of fusion, undercuts, or cold laps. In this work the finite element model of the narrow gap TIG welding was created. Based in that model, the influence of the filler wire speed on the heat distribution, side wall fusion and weld formation are shown.

PRODUCTION OF HEAT-RESISTANT ALLOYS ON A TITANIUM BASE BY ELECTRON BEAM MELTING IN UKRAINE

Akhonin S.¹, Severyn A.¹, Berezos V.¹, Kryzhanovskyi V.², Kuzmenko M.³

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The article is devoted to the production of heat-resistant titanium alloys by electron beam melting in the conditions of import substitution of the titanium products market in Ukraine. The production of ingots of industrial heat-resistant titanium alloys and new generation heat-resistant alloys with a silicide hardening mechanism is described. It has been shown that the quality and properties of material and deformed semi-finished products are at the same level, and in some cases even exceed world analogues in terms of properties.

METALLURGICAL CHALLENGES AND SOLUTIONS IN REPAIR WELDING OF Cr-Co ALLOYED STEELS: A CASE STUDY ON GAS TURBINE STATOR RINGS

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In this study, the susceptibility of Cr–Co alloyed steels to form retained austenite during repair welding, which can adversely impact material properties, was investigated. The primary focus was to reduce the formation of retained Austenite by raising the preheat temperature above the Martensite start temperature and incorporating a Martempering thermal cycle during the repair process. This approach was intended to ensure uniform temperature distribution throughout the material thickness, thereby preventing the formation of retained Austenite, which could transform into brittle Martensite during the tempering step. Additionally, the use of elevated preheat temperatures, along with Post-Weld Heat Treatment (PWHT) at 625–660 °C for 2 hours, significantly minimized the risk of hydrogen-induced cold cracking.

DEVELOPMENT OF CHEMICAL COMPOSITION AND PARAMETERS OF HEAT TREATMENT OF PEARLITIC STEELS FOR RAILWAY RAILS OF INCREASED DURABILITY

Babachenko O.I., Kononenko G.A., Podolskyi R.V., Safronova O.A.

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A system of alloying and heat treatment parameters of carbon steel has been developed, the use of which for the production of railway rails provides them with an increase in durability. By means of mathematical modeling, the regularities of the change of the thermal field along the section of the head of the rail during cooling have been established.

It is shown that the use of the developed steel makes it possible to achieve not only a hardness level of 368NV in the head of the railway rail at a depth of 20 mm, but also a structure of ultradispersed pearlite with an interlaminar distance of $0.15 \mu m$, without the formation of slag structures on the surface.

PRODUCTION OF PROMISING BIOCOMPATIBLE ALLOYS FOR MEDICAL USE BY ELECTRON BEAM MELTING

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Recently, alloys containing titanium, zirconium and niobium has been increasingly used in various fields of medicine, displacing previously widely used stainless steels and cobalt-chromium alloys. Interest in alloys with low specific gravity, high corrosion resistance and good biological compatibility has grown significantly in connection with the development of surgery to replace diseased joints with endoprostheses, as well as with the increase in the use of implants in dentistry.

With the obvious advantages of these alloys, their wider use in medicine is restrained by a number of problems, such as: low quality of semi-finished products due to violations or imperfection of their production technologies; complexity and time-consuming production technology; low mechanical properties of cast semi-finished products.

Currently, there is a significant demand for products made of alloys of this class in Ukraine; however, there is no domestic production and they are exported in significant quantities from abroad.

Therefore, mastering the technology of obtaining semi-finished products from biocompatible medical alloys in industrial conditions requires the development and implementation of fundamentally new technologies and equipment for smelting ingots and manufacturing deformed semi-finished products.

Based on the research and experimental melting conducted by E.O. Paton Electric Welding Institute, the technology of production by electron beam melting of high-quality defect-free ingots of biocompatible medical alloys with a guaranteed chemical composition and obtained ingots of various alloying systems has been developed. Studies of the quality of the ingots obtained showed that the developed technology allows to obtain ingots of promising biocompatible alloys for medical use, homogeneous in structure and chemical composition.

STUDY OF THE EFFECT OF A LASER BEAM ON THE MATERIALS OF UAV PARTS

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Work on the study of the effect of a laser beam on materials, specifically the destruction of materials from which UAV parts are made, had not been carried out in Ukraine before. This research should become one of the many steps aimed at solving the complex task of developing, manufacturing, testing and introducing into serial production mobile complexes to combat UAVs. The study of the current state of the problem and the experience of other countries shows that the path from the beginning of development in this direction to adoption is at least 5 years (on the example of DE M-SHORAD (USA). The probability that such laser mobile complexes will be in the near future sent by other states for the protection of Ukraine is quite small. Therefore, the sooner the research in this direction is started, the sooner the first results will be obtained. It is known that such a mobile complex consists of a large number of interconnected systems and modules on separate modules: the laser equipment module (for the necessary energy and time characteristics); the UAV detection module; and so on, that the proposed Project is aimed specifically at substantiating the technical parameters and characteristics of the laser equipment module of the mobile complex for combating UAVs. Such justification will be based on the results of experimental studies performed using the prototype of the laser module of the laser equipment of the mobile complex for combating UAVs.

Acknowledgments. The research was carried out at the expense of financing by the National Research Foundation of Ukraine project No. 2023.04/0166 "Study of the effect of a laser beam on the materials of UAV parts and substantiation of the technical parameters of the laser equipment of the mobile complex to combat them".

EFFECT OF MAGNETIC FIELD APPLIED DURING FUSION WELDING OF 2205 DUPLEX STAINLESS STEEL ON RESISTANCE TO FATIGUE CORROSION CRACKING

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2205 Duplex Stainless Steel (DNS) is an alloy containing 22 % Cr and 5 % Ni. The steel microstructures a d-ferrite matrix with BCC structure with face-centred intercalated cubic lattice with g-austenite in the ratio 50:50. DNS is used in industry for its high mechanical and corrosion resistance, better than ferritic or austenitic stainless steels. During the welding process a low intensity electromagnetic interaction was induced using axial external electromagnetic fields 0; 3 and 12 mT. Microstructural analysis and evaluation of localised corrosion resistance under pitting corrosion conditions were carried out. Resistance to crack formation and growth was also evaluated in a low cycle corrosion fatigue test mode to monitor short crack behaviour. Low intensity electromagnetic interaction (3 mT) was found to improve localised corrosion resistance, but at 12 mT no improvement was observed compared to 0 mT. Cracking resistance and fracture toughness were also improved by the application of 3 mT external electromagnetic fields due to the modification of microstructural evolution during the thermal welding cycle. Based on the experimental investigation, the criterion value of SIF for 2205 stainless steel duplex is determined. It was

determined that each case requires a separate study, as the impact on the durability of the structural element of any parameter is felt, but the given approach is positive because the systematic express analysis of various structural elements in aggressive environments, which can be fulfilled in engineering practice, is possible.

HEATING AND STRAIN SENSING ELEMENTS BASED ON SEGREGATED POLYETHYLENE/CARBON BLACK COMPOSITES IN POLYMER WELDED JOINTS

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The development of easy and direct real-time monitoring of welded joint quality instead of surface damage analysis is crucial to improve the quality of industrial products. This work presents the results of high-density polyethylene (HDPE)-based composites with various carbon black (CB) content (from 20 to 30 vol.%) for use as a heating element and strain sensor in electrofusion-welded polymer joints. The pyroresistive heating process was used to determine the effect of generated Joule heat during welding on the structure and sensor properties of polymer—carbon composites. It is shown that the generation of Joule heat depends on the nanocarbon content and affects the crystal-linity of the polymer matrix. The partial disruption of the conductive path of carbon black particles was observed and, as a result, a decrease in electrical conductivity for composites with lower CB content after welding was found. For the highest CB amount, conductivity increased, which is caused by smaller particle-to-particle distance for filler paths. Therefore, the best balance between pyroresistive and sensor properties was found.

WORKPLACE OF A COSMONAUT-WELDER FOR PERFORMING MANUAL ELECTRON-BEAM WELDING OF OBJECTS ON THE SURFACE OF THE MOON

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When exploring the Moon, much attention is paid to the creation of long-term lunar bases (LMB) and infrastructure for these structures. Taking into account the special physical conditions on the surface of the Moon and, first of all, the ultra-high vacuum (up to 10–11 Pa), the required tightness of the DMB structures can be ensured by welding. Therefore, in the case of human exploration of the Moon, the creation of specialized electron-beam welding equipment and auxiliary equipment, which is the workplace (WP) of an astronaut — a welder, is very relevant.

WP operator-welder, designed to perform technological and repair operations during the operation of the station modules on the surface of the Moon. It is necessary to move the operator to the place of maintenance and repair of the shell of the space module with the possibility of its lifting, tilting and rotation around the vertical axis.

When performing work in an orbit around the Earth, which has a height of about 300 km, the movement of the flying object is accompanied by frequent changes of day and night — for every 90 min of flight, a person is in the dark for 45 min. At the same time, human adaptation to the sun's rays, the brightness of which doubles, also becomes relevant. Therefore, it is necessary to create artificial lighting of the astronaut welder's workplace when working in complete darkness.

In the "Space Technologies" department of the PWI working project was developed for the manufacture of an astronaut-welder WP, which is adapted to perform electron beam welding and related technologies with a hand tool in Earth orbit or on the surface of the Moon. When performing these works, the features of the Moon's surface and, first of all, reduced gravity compared to the Earth, low temperature, and the presence and action of lunar dust (regolith) were taken into account.

The main technical characteristics of the WP of the cosmonaut-welder are such as transport dimensions, mass characteristics, service area, the choice of the chassis design of the mobile WP, as well as the specific choice of the electric drive and its power supply (autonomous, solar battery, battery or onboard network of the space station). The WP should be made in the form of a folded structure, which in the transport position occupies a minimum volume with a minimum weight, depending on the selected construction material.

In this work, the object of research and calculations was the typical design of the lunar module of the enterprise KB "South". The horizontal orientation module is a welded aluminum structure made of a cylindrical shell, frames and torospherical bottoms. The external diameter of the module is 3000 mm, and the WP supports can be adjusted in height by 100 mm.

Taking into account these factors, several variants of constructions of the WP cosmonaut-welder were proposed and considered in compliance with the main requirements: minimum dimensions in the transport position, a limited number of movable elements from the point of view of the influence of lunar dust — regoliths, minimum weight of the structure, thanks to the selected heat-strengthened aluminum alloy 2219 with a heat-reflective coating over the entire surface of the structure. At the same time, the convenience and ease of transfer from the transport position to the working position is ensured. Convenience of performing technological works can be provided by the position of the operator in different positions of the manipulator: from the minimum lower position to the maximum upper position. The possibility of intermediate positions of the operator is also provided, for example, when working to eliminate defects on the surface of the roof of the module. In this version, the position of the operator is tilted. Given the effect of reduced gravity, of course, the comfort of performing technological work deteriorates, for which the operator must be securely fixed in relation to the work object.

SOME FACTORS AFFECTING INTER-LAYER WELD STRENGTH IN MATERIAL EXTRUSION 3D PRINTED AMORPHOUS AND SEMICRYSTALLINE POLYMERS

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Material extrusion 3D printing is an innovative polymer processing route which allows fabrication of parts with complex and customized geometries. The extent of welding occurring between the layers largely affects the mechanical response. We conducted experiments and molecular modeling on both amorphous and semicrystalline polymers. It is shown that the presence of residual alignment of the chains at the weld and a faster crystallization rate are detrimental for the weld strength.

USING SPECTRAL PARAMETERS OF COMPRESSED ARC PLASMA TO DEVELOP BASIC APPROACHES TO SMART WELDING

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It is proposed to analyze the spectral composition of the arc plasma on-line by pre-selected lines using CCD detectors with a sensitivity range of 190~1100 nm and a response time of 4 ms. The analysis performed will allow recording the overall temperature (energy) of the plasma and the stability of welding. The information obtained will be analyzed by self-learning neural networks to improve the quality of automated control of welding processes.

RELATIONSHIP BETWEEN STRESS CONCENTRATION AND STRESS INTENSITY FACTORS IN SHARP OR ROUNDED V-NOTCHES IN ORTHOTROPIC PLANE

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By using the singular integral equations of the plane problem of the theory of elasticity for anisotropic body with cracks, integral equations for an orthotropic plane containing curvilinear holes with rounded vertices have been constructed. By using the limit transition when the radius of curvature of vertex tends to zero, the stress intensity factors in sharp vertices of the holes have been found. Stress intensity and concentration factors for the lens-like with sharp and rounded vertices have been studied.

HYDROGEL MATERIALS BASED ON POLYVINYL ALCOHOL AND SILVER NANOPARTICLES, CROSS-LINKED BY ELECTRON BEAM IRRADIATION

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Every year, millions of people suffer from chronic diseases, injuries, various types of thermal burns, fractures or bone defects. Therefore, the idea of developing a non-toxic, antibacterial cross-linked hydrogel material is currently relevant.

Polyvinyl alcohol based hydrogel nanocomposite materials were obtained by chemical reduction of silver ions followed by cross-linking by irradiation with an electron beam. High antimicrobial activity of hydrogel nanocomposites against conditionally pathogenic microorganisms S. aureus and E. coli was revealed.

This work was partially realized in the frame of the project from the National Research Foundation of Ukraine (Development of biopolymer nanocomposite materials to stimulate the regeneration of living tissues and wound healing). Application ID 2023.05/0009).

FEATURES OF PHASE AND STRUCTURAL TRANSFORMATIONS IN Ti/Cu MULTILAYER FOILS WITH EUTECTIC COMPOSITION DURING HEATING

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It is known that multilayer foils (MF), consisting of alternating layers of reactive components, are characterised by a pronounced heterogeneous structure and a significant reserve of internal energy. Such reactive MF can be used as localised heat sources for rapid brazing or as intermediate layers during diffusion welding of materials that are difficult to deform. On the other hand, it is known that the formation of nanostructured and metastable components can lead to a reduction in the temperature of phase and structural transformations during the heating of the MF. This can be useful when MF consisting of layers of eutectic system components are used as solder in brazing materials sensitive to thermal exposure. From this perspective, MF of the Ti–Cu system, whose components are the basis of well-known solders for high-temperature brazing of various materials (such as Ticuni 70, VTi-1, MBF 5012, etc.), deserve special attention.

Using layer-by-layer electron beam deposition of components in a vacuum, two types of Ti/Cu MF were produced: eutectic composition I (Ti50–Cu50 wt.%) and eutectic composition II (Ti22–Cu78 wt.%). The alternating period of the component layers in the studied MF varied from 150 to 700 nm.

It was shown for the first time that the onset of melting in Ti/Cu multilayer foils (MF) with a component ratio corresponding to the high-temperature eutectic composition Ti50-Cu50 (wt.%) can occur at a lower temperature, ap-

proaching the melting temperature of the low-temperature eutectic composition Ti28–Cu78 (wt.%). The reduction in the melting temperature of MF with eutectic composition I may be related to the formation of a heterogeneous structural state during heating, which includes metastable intermetallic compounds TiCu₄ and Ti₂Cu₃, components of the low-temperature eutectic composition II. To ensure the reduction of the melting temperature of MF with the eutectic composition I, the modulation period of the layered structure must exceed a certain critical value, which would prevent the complete mixing of the component layers during heating and the formation of a homogeneous structure before the melting temperature of the low-temperature eutectic is reached. Such behaviour of MF with eutectic composition I may facilitate the softening of the temperature conditions necessary to establish physical contact in the material bonding zone during reactive soldering.

HYBRID 3D PRINTING AND WELDING TECHNOLOGIES

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This article explores in detail hybrid technologies that combine 3D printing and welding to produce complex metal structures. The paper analyzes the main advantages and technical challenges faced by engineers when integrating these two processes. Examples of successful applications of the technologies in industry are discussed, as well as prospects for the development of these methods. Particular attention is paid to the study of mechanical properties and microstructure of materials used in hybrid technologies.

POLARIZATION RESISTANCE METHOD FOR NON-DESTRUCTIVE TESTING OF CORROSION RATES IN LOCALIZED AREAS OF A WELDED JOINT

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The method of non-destructive testing of the corrosion rate in localized zones of a welded joint is based on measuring the polarization resistance in a scheme of two dissimilar electrodes: working electrode — a localized area of the welded joint; the auxiliary electrode is either unpolarized or polarized with a much larger surface area than the working electrode. The localization of the corrosion process is ensured by the use of an overhead pressure cell with a restrictive hole.

DEVELOPMENT AND APPLICATION OF EB-PVD TECHNOLOGY FOR THE SYNTHESIS OF METAL NANOPARTICLES FOR MEDICAL USE

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Electron beam technology (EB-PVD) was developed to obtain nanoparticles of metals Ag, Cu, Fe without impurities, which is important for medical preparations. Studies have shown that metal nanoparticles can be used as active components in various dosage forms, improving their properties, in particular, antimicrobial activity. Microbiological studies have confirmed the antimicrobial properties of drugs with silver and copper nanoparticles. The safety of silver nanoparticles with a size of 15–20 nm has also been established, and new technological schemes allow obtaining nanostructures in the volume of liquids and on the surface of powders of various substances.

EFFECT OF RESTORATIVE CLADDING WITH VT22sv FILLER WIRE AND LOCAL HEAT TREATMENT ON THE FATIGUE PERFORMANCE OF VT22 ALLOY SAMPLES WITH A HOLE

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Mechanical properties of VT22 alloy samples subjected to restorative argon arc cladding using VT22sv filler wire in an argon environment with the application of an external alternating magnetic field, followed by local heat treatment (LHT) was investigated. Good results in terms of minimizing the penetration depth, heat-affected zone, and welding defects, specifically pores in the deposited layer were obtained. Low number of pores with diameters within 0.1 mm, and the effectiveness of LHT contributed to the improved mechanical properties.

SYNERGIZING MELT POOL GEOMETRY METRICS AND ACOUSTIC ANALYSIS FOR ENHANCED DEFECT DETECTION IN GMAW AND WAAM

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This research investigates the integration of melt pool geometry metrics with acoustic analysis to improve defect detection in Gas Metal Arc Welding (GMAW) and Wire Arc Additive Manufacturing (WAAM). By employing the near-infrared spectrum through the Xiris XVC-750 weld camera, we enhance the visibility of the GMAW weld pool, facilitating the use of advanced machine learning tools such as Xiris MeltPool AIô for real-time weld pool recognition, segmentation, and measurement. The resulting segmentation mask provides multiple geometric features that are sensitive to variations in weld bead geometry, contamination, and shielding gas deficiencies. Simultaneously, changes in weld sound, captured using Xiris WeldMicô and analyzed with Audio AIô software, are examined through audio feature extraction methods, including spectrum analysis and Mel-frequency cepstral coefficients (MFCCs). This study offers a comparative evaluation of the effectiveness of these individual methods and their combined use in detecting weld defects and geometric anomalies. The fusion of melt pool geometry metrics with acoustic analysis shows significant promise for advancing defect detection in welding and additive manufacturing processes.

THE NANOMODIFICATION INFLUENCE ON THE LOW ALLOY STEEL WELD METAL MICROSTRUCTURE FORMATION

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In order to expand the knowledge base regarding the of low-alloy steels welds metal features modification, studies on the nano-sized refractory particles inoculation of oxides Al_2O_3 , TiO_2 , MgO, ZrO_2 into the welding bath were performed. It is shown that the oxides inoculation with a low level of mismatch to the δ -Fe lattice and increased wetting with liquid iron (MgO, ZrO_2) into the weld pool contributes to the dendrites growth, which are formed during melt crystallization. Metal modification with MgO, ZrO_2 oxides contributes to a decrease in the polygonal ferrite hardness and an increase in the lower bainite content in the welds microstructure, increasing the welds metal resistance against brittle fracture. Metal modification with oxides Al_2O_3 , TiO_2 contributes to an increase in the polygonal ferrite hardness and an increase in the upper bainite content in the welds microstructure, growth the low-alloy steel welds strength indicators.

BIBLIOGRAPHIC INDEX "WELDING AND RELATED TECHNOLOGIES"

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The bibliographic index "Welding and Related Technologies" has been published by the Scientific and Technical Library of the E.O. Paton Electric Welding Institute of the National Academy of Sciences of Ukraine since 1994 and it is the main source of up-to-date scientific information for library users today. Over the 30 years of its existence, it has grown into a substantial archive of reference and bibliographic information and shows trends in the field of welding and related processes. Publication of this signaling information contributes to the intensification of electronic orders for copies of documents from the library's collections, which are sent to the corporate e-mail box library_paton@ukr.net from users.

PERIODICALLY NON-STATIONARY PROPERTIES OF VIBRATIONS FOR GAS-TURBINE ENGINE WITH UNBALANCED ROTOR

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The low-frequency vibrations (2 kHz) of gas-turbine engine are analyzed on the basis of their model in the form of periodically non-stationary random processes (PNRP). It is shown that the power spectrum of the raw signal is mixed. The least square method is used for discovering of the hidden periodicities of the first and second orders. The frequencies of the deterministic basic harmonics are estimated and amplitude and power spectra of the deterministic oscillations are found. These spectra are compared for the cases of balanced and unbalanced rotors. It is show that the power on the first harmonic for the unbalanced rotor is dominant. The interpolation formulas for the time dependences of PNRP mean function are obtained and the vibration stochastic parts are separated. It is revealed that for unbalanced rotor the variance is the time periodical function, basic frequency of which is closed to the rotation frequency. This properties is caused by the appearance of the distribute fault.

LASER SYNTHESIS OF CBN-CONTAINED ABRASIVE LAYERS

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Cubic boron nitride (CBN) is widely used for abrasive disk manufacturing for steel processing. In the given work some aspects related to the increase of manufacturing productivity for the abovementioned cutters are portrayed, as well as technological processes of laser synthesis for the manufacturing of abrasive layers. Results of laser irradiation absorbability by the CBN depending on its state or on its powder dispersion and surface roughness, heating regimes and initial temperature are presented in details

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LASER FORMING OF STEEL SHEETS

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Laser forming (LF) of sheet materials is flexible method of forming. From the other side, in abrasive tool industry it is important to produce metallic frame (with specific shape) as a base for abrasive layers which could be produced by LF.

Specific of LF of complicated shape is shown. Structural transformations in carbon steel during repeated laser irradiation are discussed. Results of LF experimental research are presented.

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DIGITAL X-RAY TELEVISION SYSTEMS FOR NDT

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The E.O. Paton Electric Welding Institute of the NAS of Ukraine offers new principles for constructing digital radiation monitoring systems that minimize their cost while maintaining a wide range of functionality in accordance with customer requirements. Has been developed a hardware and software complex that is oriented for use with various types of detectors: X-ray television scanners, X-ray television systems based on scintillation crystals and screens, flat panel detectors, etc.

Mg-Ga-Zn-Ca ALLOYS AS A PROMISING MATERIAL FOR THE PRODUCTION OF BIODEGRADABLE IMPLANTS

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Magnesium alloys, in particular alloys with zinc, calcium and gallium, are a promising material for the production of biodegradable implants for treatment of bone injuries and diseases due to its biocompatibility and proximity of mechanical properties to those of bone tissue.

It was established that mechanical properties (Young's modulus, plasticity coefficient, microhardness, UTS) of these alloys exceed the values of basic magnesium alloys and also show a lower corrosion rate. An alloy Mg-3.5Ga-3.5Zn-1Ca showed an overall best performance.

MODELING OF TEMPERATURE FIELDS DISTRIBUTION AND STRESS-STRAIN STATE OF Mg-AI ALLOY FSW JOINTS

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Computer modeling methods are an effective tool for optimization of welding processes due to economy of time and materials and achieving optimal joint properties. A model was developed to estimate the distribution of temperature fields during the friction stir welding process and subsequent stress-strain states in the joint, based on experimental

values (Young's modulus and surface temperature distribution) and material's density, specific heat capacity, and thermal conductivity coefficient, allowing to predict its service life.

PROSPECTS FOR THE DEVELOPMENT OF MODERN NON-CONTACT THERMOSURGICAL TECHNOLOGIES

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An analysis of experimental and clinical data on the main types of surgical interventions using non-contact surgical technologies with various physical factors has been conducted. Using the principles of evidence-based medicine, the possible application areas of non-contact surgical technologies have been determined, which include the use of laser radiation, visible, infrared, and ultraviolet light, convective high-temperature flows, NO-plasma and other types of plasma, UHF, and soft X-ray radiation.

It has been established that the use of a combined high-temperature convective-infrared flow ensures 99.9 % effectiveness in sanitizing infected wounds, including polymicrobial cultures, and 95 % sanitization of purulent wounds infected with antibiotic-resistant polymicrobial cultures.

A comparative analysis of the effects of convective-light flows of different ranges on microbial cultures in wounds revealed minor differences in antimicrobial effectiveness, with significant operational advantages of the convective-infrared flow. An important operational advantage is the use of modern infrared LED-based components.

An analysis of the prospects for the use of surgical laser scalpels suggests that systems with a power range of 80-200 W, combined with automated 2D systems for controlling trajectory and movement speed, represent one of the most promising directions for the further development of non-contact electrosurgical technologies.

CORROSION RESISTANCE OF INCONEL 601 IN STATIC LEAD MELT AT 450 AND 650 °C

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The results of a study of the corrosion behavior of INCONEL 601 in static lead melt with limited oxygen access at temperatures of 450 and 650 °C for 1440 h with an intermediate study of samples after 240, 480, 720 and 1000 h of testing are presented. It was found that increasing the temperature from 450 to 650 °C leads to an increase in the rate of steel corrosion by more than 10 times already after 240 hours of tests. On the other hand, an increase in the duration of the tests from 240 to 1440 hours is characterized by a tendency to decrease the value of the index by ~1.7 times at the melt temperature of 650 °C and ~11.5 times at the melt temperature of 450 °C, which is explained by the formation of surface-blocking protective oxide films and products corrosion. The steel surface morphology of the formed oxide deposits, the structure and elemental composition were studied by X-ray spectral microanalysis (XSMA) with an energy dispersive spectrometer (EDS). The results of optical microscopy and durometric analysis are also presented. It has been established that after 240 hours of testing, a layer of corrosion products of a dense sandwich-type structure is formed, consisting of O, Al, Cr, Fe, Ni and Pb with a clear separation of layers that differ in composition into those adjacent directly to the base metal (O, Al, Cr, Fe, Ni and Pb) and in contact with molten lead, predominantly consisting of O, Ni and Pb, and already after 1440 hours — lead penetrates deep into the base metal.

SUSTAINABLE MANUFACTURING OF VERTICAL CARBON NANOTUBE ARRAYS INSIDE INSULATING NANOPOROUS MEMBRANES USING NICKEL NANOWIRES

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Carbon nanotubes (CNTs) were successfully synthesized using industrial waste gases by chemical vapor deposition inside the vertically-oriented nanopores of insulating membranes. The gaseous waste products from Fischer–Tropsch synthesis were used as the carbon source. In this study, vertical CNT arrays were achieved using nickel (Ni) nanowires catalysts that were prepared by template electrochemical deposition inside 50 nm thick nanoporous anodized aluminum oxide (AAO). Here, the nanopore diameter (20–200 nm) and Ni MNW length (45 and 25 nm) were varied to study the impact on CNT growth characteristics. Raman spectroscopy, scanning electron microscopy, transmission electron microscopy, and field emission were used to characterize CNTs on Ni MNWs. For long MNWs (45 nm), the Ni catalyst was just below the AAO surface, so CNT diameters did not change appreciably with MNW diameter. Alternatively, for short MNWs (25 nm), the carbon source gases had to diffuse into the AAO nanopores before reacting with the Ni catalyst, and both the CNT diameter and yield increased with nanopore diameter. Highly crystalline CNTs were formed from particles of Ni catalyst, although for smaller diameter nanopores, the Ni catalyst particle could be blocked by template wall defects, resulting in subsequent amorphous nanofiber growth above the blocked particle. Optimally CNT synthesis was observed for 25 μ m MNWs grown in 80 nm AAO nanopores, maximizing field emission current at 150 μ A (at electric field 0.5 V/ μ m) with a turn-on field of 0.26 V/ μ m. These aligned CNTs can further be used to produce matrix composite heating elements for welding of plastics.

STRENGTH PROPERTIES AND CRACK RESISTANCE OF STRUCTURAL MATERIALS WITH MULTIPHASE PLASMA COATINGS

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The physical and mechanical properties of multiphase plasma coatings containing a complex structure, including nanoscale, are considered. The proposed method of calculating the parameters of crack resistance is based on the energy evaluation in the "base–coating" system and on the study of its strength properties. It becomes possible to evaluate the processes of cohesive cracking and adhesive delamination during the bending test of coated specimens using appropriate approaches for each process.

CHEMICAL COMPOSITION AND MORPHOLOGY OF ELECTRODEPOSITED Ni-Mo COATINGS FROM A SELF-REGULATING ELECTROLYTE

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Electrochemical Ni-Mo coatings were obtained on a low-carbon steel substrate using a stable, environmentally safe, self-regulating electrolyte containing

0.2 M NiCl₂, 0.3 M Na₃C₆H₅O₇, and SrMoO₄ (saturated). The effects of electrolyte pH, temperature, deposition current density, and hydrodynamic conditions on chemical composition and morphology of the coatings were studied. It was established that the addition of ammonia to the electrolyte contributes to the deposition of a more uniform,

globular, nonporous coatings morphology. The effect of ammonia on the formation mechanism of coatings was substantiated. The stages of deposition and the limiting stage of the formation of Ni–Mo coatings from citrate-ammonia electrolytes, which involves the chemical reduction of molybdenum oxide (IV) to molybdenum, were determined using cyclic voltammetry.

EVALUATION OF THE EFFICIENCY OF ENERGY TRANSFER FROM A LASER-PLASMA JET TO HEAT INTO METAL WHEN WELDING CARBON AND STAINLESS STEELS

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The effectiveness of energy absorption during laser, plasma, and laser-plasma welding of carbon and stainless steels using fiber laser radiation was investigated. It is shown that during laser-plasma welding, the energy absorbed by the metal is 5–6 % higher than the arithmetic sum of absorbed energies under the separate action of laser radiation and plasma arc. This is mainly due to an increase in arc voltage in the process of laser-plasma welding compared to plasma welding.

USING AN AUTOMATIC MONITORING SYSTEM TO AUTOMATE THE MANAGEMENT OF WELDING AND 3D PRINTING PROCESSES

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The concept of creating a multi-information system for collecting and analyzing infor-mation for automatic monitoring of welding and 3D printing processes is proposed, which is based on the application of neural networks with self-learning and information data-bases with relevant parameters of welding processes. Based on the action of such neural networks, feedback for automated control of these processes will be implemented in the system, which will allow creating an automatic monitoring system capable of controlling welding and 3D printing processes in real time.

DETERMINATION OF THE KEY TECHNOLOGICAL FACTORS OF OBTAINING HIGH-QUALITY WELDED JOINTS OF THE D16 STRUCTURAL ALUMINUM ALLOY BY THE ADAPTED PROCESS OF AUTOMATIC PULSE-ARC WELDING WITH A FUSIBLE ELECTRODE

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Based on the work carried out in the 60's and 70's of the last century, it was generally accepted that the D16 alloy of the Al–Cu–Mg system is not weldable by fusion welding due to its high tendency to form crystallization cracks. In 2010 in the department No.7 EWI them Paton's work was carried out to develop and implement the technology of repair manual welding with a non-fusible electrode of frames made of D16t alloy.

Positive results were obtained, in the absence of deep and through crystallization cracks. This is due to the use of filler wires with the appropriate chemical composition and optimal welding modes. This work later allowed to create a concept and methodology for further development of the industrial technological process of automatic fusion welding of structures made of D16 alloy.

Development and modification of the equipment which allows to carry out process of arc welding by melting with alloying of a welded bath by an additional filler wire is carried out.

Welding of the first samples by different chemical composition of welding filler wires on repeated modes is carried out.

Work is underway on the final selection of welding materials, optimization of modes and improvement of equipment to ensure obtaining satisfactory mechanical properties of welded joints.

The obtained results, in particular, the absence of crystallization cracks and the close strength of the weld metal to the base metal, along with the allowable number and shape of internal defects give grounds to continue work in this direction, especially with regard to ensuring a sufficient level of plasticity of the welded joint.

SOME FEATURES OF EXPERIMENTAL STUDIES OF ACTIVATION OF THE PLASMA WELDING PROCESS

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Increasing the melting ability of the plasma arc while minimizing the linear energy is one of the main tasks of increasing the efficiency and expanding the technological possibilities of using the plasma welding (PW) process.

Some features of the influence of the activating (including synergistic) effect on the melting ability of the arc when applying various methods of activating of the PW process are considered, using namely: activating flux PATIG C (FA-PW process); shielding gases and their mixtures (Ar, H_2) (GA-PW process); modulation of the welding current by high-frequency pulses (HFP) (f = 6-20 kHz) (HFP-PW process); combined use of two activating factors — activating flux together with HFP modulation of the welding current (FA-HFP-PW process).

The effectiveness of the activation of the PW process was evaluated during bead on plate welding of 6 mm thick 304 stainless steel plates at an average welding current in the range of 70–110 A, which corresponds to the range of changing the effective power of the arc — 800–2700 W.

It is shown that, according to the degree of increase in the depth of penetration of the weld metal, the activated PW methods can be arranged in the appropriate series: $GA-PW \rightarrow HFP-PW \rightarrow FA-HFP-PW$.

It has been established that when using different activation methods, compared to the conventional PW process in argon, the penetrating power of the plasma arc (depth of penetration) can increase from 1.4 to 4 times.

LASER WELDING USING DYNAMIC BEAM SHAPE. TECHNOLOGY AND PRACTICAL APPLICATIONS

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Laser welding provides a high-performance process for joining materials with various thicknesses in a wide range of modes. Among the main advantages — are high productivity, accuracy, and stability of the heating spot trajectory. High energy densities provide deep penetration and at the same time narrow heat-affected zone as well as minimal deformation of welded parts.

Modern laser complexes can significantly expand the technological capabilities of welding processes. At the same time, traditional welding methods either do not use beam shapes or often employ static beam shapes, limiting their adaptability and precision. However, by harnessing dynamic beam shapes, such as variable spot sizes, beam shapes,

frequencies, and trajectories, researchers can achieve unparalleled control overheat input, penetration depth, and weld bead morphology.

The new laser laboratory at the Israel Institute of Materials Manufacturing Technologies, created as part of the LAMP consortium, is equipped with the most powerful and advanced laser in Israel in the field of material processing. Laser-based on Coherent Beam Combining (CBC) technology with wavelength 1064 nm and 14kW power.

The properties and features of a 14-kilowatt optical phase array (OPA) laser will be described during the seminar. We will also showcase practical examples of its application in the Israeli industry. This includes demonstrations of welding of aluminum, armor steels, and various cases of dissimilar welding.

FEATURES OF THE TECHNOLOGY OF ELECTROSLAG WELDING OF LOW-ALLOY STEEL 09G2 WITH A THICKNESS OF 20 mm WITH WIRES OF SMALL CROSS-SECTION

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According to the statistical data of the Ukrainian market of metal constructions the demand for various products increased significantly in 2023. In connection with the restoration of energy facilities and other infrastructure objects, thick sheet steel has become scarce. The same trend will be observed in the following years.

In accordance with the requirements of regulatory and technical documentation, electroslag welding (ESW) of metals of almost any thickness is carried out by various methods using electrode wires with a diameter of 3 mm. However, for welding metal with a thickness of 20 mm, the use of the specified wires requires a disproportionately large gap between the edges, high material consumption, and increased heat input.

To assess the possibility of obtaining a high-quality welded joint, to compare the nature of the process flow, thermal cycle, mode parameters and their influence on the formation of the structure of the weld metal and HAZ and mechanical properties, experimental studies were carried out of ESW of steel 09G2 with a thickness of 20 mm using ER70S-6 wires with a diameter of 1.6, 2.0 and 3.0 mm and AN-8 flux. Welding with wires with a diameter of 2.0 and 3.0 mm was performed from a power source VDU1201, and for a diameter of 1.6 mm, an inverter source OTC P500L (Japan) was used. A visual evaluation of the process showed a calmer and more stable nature of the flow of the electric current on the reverse polarity when the wire diameter was reduced. The conducted studies showed the possibility of obtaining high-quality welded joints from steel with a thickness of 20 mm with the ESW method. The use of 1.6 mm diameter wire allowed the usage of standard welding equipment with lower power sources and high speed wire feed mechanisms. The use of small-diameter wires made it possible to reduce the welding gap from 27 mm for a 3.0 mm wire to 21 mm for a 1.6 mm wire, reduce the cost of welding material, increase the welding speed, and reduce the level of heat input. A comparison of the mechanical properties and microstructure of the samples will be made on the next step of studies.

MODELING OF LASER BEAM ENERGY TRANSFER FOR THERMAL PROBLEMS IN LASER PROCESSING

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An expression has been derived to describe the propagation vector of wave energy for a spherical light wave at any given spatio-temporal point. The principles of beam transformation through an optical system are outlined. The intensity distribution across the cross-section of a laser beam is approximated using a specific function, and a calculation scheme is proposed for splitting the beam into circular and radial zones. The power characteristics of each beam have been determined.

DIRECT AND INVERSE THERMAL PROBLEMS IN LASER FORMING

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The mechanisms of thermal forming and the potential influence of equipment parameters on processing outcomes are discussed. The thermal problem in laser forming is formulated, and a possible solution using an iterative method is presented. An example of solving the inverse thermal problem is also provided.

MATHEMATICAL MODELING OF HEAT AND MASS TRANSFER PROCESSES OF ELECTRON BEAM MELTING OF SMALL-DIAMETER INGOTS OF HIGH-STRENGTH TITANIUM ALLOYS

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The development of effective technical solutions and the search for optimal management modes of existing processes is a priority task of modern metallurgy. When creating and implementing various technologies of metallurgical production, the level of knowledge about the mechanisms of heat and mass exchange development in high-temperature heterogeneous systems of different levels of interaction and complexity is of great importance.

Solidification of metal is accompanied by complex and rapid physical processes of heat transfer, hydrodynamic flow, and radiation. In practice, it is often not possible to measure the values of the parameters of these processes, especially with sufficient accuracy. Therefore, numerical calculations with the use of mathematical modeling methods are of great importance, which make it possible to draw up a qualitative and quantitative picture of the phenomena occurring in metallurgical processes at relatively low costs and a minimal amount of experimental data.

In E.O. Paton Electric Welding Institute developed a mathematical model of temperature fields and laminar hydrodynamic flows during electron-beam melting of TA15 titanium alloy, which made it possible to determine the geometry of the liquidus-solidus interphase transition zones. The zone determines the crystallization front of the metal, the position and geometry of which significantly affects the quality of the ingot formation. The necessary parameters of the melting process of a small diameter 150 mm ingot of TA15 alloy with such a crystallization front were determined by calculation, which ensures the production of high-quality metal with a uniform distribution of alloying elements in the volume of the ingot and a uniform structure. It was found that the power of the electron beam and its distribution over the surface of the bath mainly affect the heat and mass exchange in the liquid metal, and the heat transfer is caused mainly by the heat and mass exchange of the moving melt. According to the calculated regimes in E.O. Paton Electric Welding Institute smelted high-quality TA15 alloy ingots.

MODELLING OF TUNGSTEN INERT GAS ARC AND ITS IMPACT ON THE ANODE SURFACE

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An unified mathematical model of plasma column and anode region of electric arc with refractory cathode in inert gas of atmospheric pressure, in particular welding arc in TIG welding, is described. An essential feature of this model is the possibility of taking into account the non-uniformity distribution of anode voltage fall in the region of anode binding of the arc, that allows a more adequately description of the electric current distribution in the near-anode plasma. The model allows calculation of thermal, gas-dynamic and electromagnetic characteristics of arc plasma, as well as the characteristics of its thermal, electric and force impact on the anode surface, depending on the arc current

and length, kind of shielding gas and anode material. Model testing and verification were performed, the results of which are indicative of the model adequacy and its applicability for numerical study of the above characteristics.

CHARGE AND HEAT TRANSFER FROM ARC PLASMA TO METAL PARTICLE IN GMA WELDING OR PTA SURFACING

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Atmospheric pressure argon arc plasma with metal spherical particle is studied numerically. The particles of the radius of 10^{-5} – 10^{-4} m and 10^{-3} m are considered. That corresponds to particles of additive material in plasma transferred arc (PTA) surfacing and droplets of electrode metal in gas metal arc (GMA) welding, respectively. The plasma is described in a hydrodynamic approach with account for its thermal and ionization non-equilibrium near the particle. The electric current flowing through the particle and the heat flux transferred to the particle in the arc plasma are found.

INFLUENCE OF MICROSTRUCTURE OF Co-35 wt.% Ni COATINGS ON THEIR DISSIPATIVE PROPERTIES

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Damping coatings are considered an effective means to reduce the amplitude of resonant vibrations of elements in complex mechanical systems, such as titanium blades in a gas turbine engine. However, applying this approach to inhibit resonant vibrations in parts made from high-Q materials requires surface deposition techniques and materials that provide the coating with not only high damping capacity but also superior strength and corrosion resistance. In this regard, special attention is given to cobalt alloys, whose high damping capacity is attributed to the magnetomechanical dissipation of oscillation energy. Considering that the microstructure characteristics of the alloy may change during electron beam deposition, a study was conducted to investigate the influence of the microstructure of Co–35 wt.% Ni alloy coatings on their intrinsic damping capacity.

A high level of damping is observed when the coating's microstructure has a high density of subgrain boundaries. Conversely, a low density of subgrain boundaries results in low damping. It was concluded therefore that achieving high damping in Co–35 wt.% Ni ferromagnetic coatings requires deposition and heat treatment conditions that increase subgrain boundary density.

FEATURES OF THE FORMATION OF A DIRECTIONAL STRUCTURE OF COMPLEX-PROFILE CASTINGS

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The thermophysical features of the formation of a directional structure of complex-profile castings (a turbine blade for a stationary gas turbine engine) from the SM88Y alloy in the UVNK-8P vacuum plate with variations in the crystallization rates $V_{\rm cr}=2$; 5; 10 mm/min were studied experimentally and analytically. The dependences of the change in the temperature gradient at the crystallization front and the speed of movement of the front on its position in the crystallizing casting were obtained. Metallographic analysis shows that with selected optimal crystallization parameters, a regular dendritic structure is formed along the entire length of the product, including transition sections.

ANALYSIS OF THE INFLUENCE OF CMT AND PULSE GMAW SURFACING METHODS AND THE CHEMICAL COMPOSITION OF THE PROTECTIVE GAS ENVIRONMENT ON THE FORMATION AND METAL STRUCTURE OF ADDITIVELY FORMED PRODUCTS FROM G3SI1 STEEL AND CUSI3MN1 ALLOY

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The results of studies on the influence of CMT and Pulse methods of arc surfacing with a consumable electrode and the composition of the shielding gas on the formation and structural-phase composition of metal during the additive synthesis of products from G3Si1 steel and CuSi3Mn1 alloy are presented. The influence of the composition of the shielding gas environment and methods of electric current supply on the mechanical properties of the deposited metal from low-carbon steel was determined.

SCIENTIFIC PRINCIPLES OF MAGNETIC PULSE TREATMENT OF WELDED JOINTS IN THE PROCESS OF FUSION WELDING

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Treatment of welded joints with a pulsed electromagnetic field (TPEMF) reduces the level of residual welding stresses. PEMF during welding increases the efficiency of the welding process (compared to PEMF after welding) and makes it easier to implement. On the basis of mathematical modeling and experimental studies of magnetic pulse processes, an automated complex for TIG welding has been developed that is compatible with the OIEMP of the weld metal under the conditions of a thermo-deformation welding cycle.

AUTOMATED SHEAROGRAPHY FOR DETECTION OF SUBMILLIMETER DEFECTS IN THIN-WALLED ALUMINUM WELDS

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A shearographic device based on a modified Michelson interferometer was used for non-destructive testing of 2.5 mm thick aluminum samples produced via friction stir welding. Blind holes, ranging from 0.3 to 1 mm in diameter, were introduced in both the weld and base metal. Optimal thermal loading parameters were established, enabling rapid identification of these defects. The system effectively detected flaws starting from 0.3 mm in diameter at varying depths in the aluminum welded joints.

APPLICATION OF AN UNMANNED AERIAL VEHICLE WITH AN RTK MODULE AND PHOTOGRAMMETRY METHOD FOR REMOTE DETERMINATION OF THE VERTICALITY OF THE KYIV TV TOWER

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The study of a TV tower using unmanned aerial vehicles equipped with an RTK module and the photogrammetry method demonstrated effectiveness in determining the verticality of the infrastructure object. The RTK technology was used to determine the geospatial position of the digital camera, allowing the creation of detailed 3D models. A methodology was proposed for determining the deviation of the central axis of the TV tower from the vertical direction based on data obtained through photogrammetry.

SCIENTIFIC PROVISIONS FOR THE TECHNOLOGY OF WELDING LONG-LENGTH DEPLOYABLE SHELL STRUCTURES FOR SPACE PURPOSES

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The paper presents a brief analysis of the technological aspects on providing the quality of welded joints of a thin-walled deployable structure, that are capable to maintain mechanical properties and ensure the vacuum density of a load-carrying shell at multiple extreme deformation. The optimal conditions for the formation of welds of thin transformable shells of austenitic steel were determined and experimentally proved, whose combination of physical and mechanical properties and structural features is as close as possible to the similar properties of the base metal.

CHANGE IN THE ENVIRONMENT COMPOSITION DURING ELECTRIC-SPARK ALLOYING OF STEEL BY Cr-, Ti-, AND Zr-ANODES

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The purpose of the work is to study the influence of the change of interelectrode environment at Electric-spark alloying (ESA) by Cr-, Ti-, Zr-anodes on the structure, phase composition, and microhardness of the St3 steel surface layers. The possibility of creating coatings with a microhardness from 5.2 to 6.8 GPa, and the thickness from 35 to 50 nm during ESA in variable interelectrode environments (argon-propane-butane or propane-butane-argon) is shown. It was established that the increase in microhardness is caused by the formation of carbides of alloying elements (Cr₇C₁, TiC, ZrC) in the surface layer.

DISCOVERY OF A NEW HIGH-SPEED PLASTIC WELDING PROCESS BY ELECTRIC EXPLOSION

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Rapid developments in global technologies have increased dependence on polymer materials. This observation leads to the exploration of potentially faster methods for creating welded joints, suggesting that innovative electric

spark welding could reduce welding times. This research focuses on the experimental exploration of polymer welding through electric discharge. This method not only allows for the rapid formation of welded connections but also maintains the necessary strength to withstand mechanical testing.

ROLE OF DEFECTS IN DEGRADING THE STRENGTH OF JOINTS BETWEEN AZ31B AND Ti-6Al-4V ALLOYS PROCESSED BY COLD METAL TRANSFER WELDING

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In this study, 2 mm thick Ti–6Al–4V and AZ31B sheets were lap joined using cold metal transfer welding with the use of 1.2 mm diameter AZ31B filler wire. It shows that joints obtained at WFS 3.4 m/min have a better weld bead appearance in comparison the joints obtained at WFS of 3.2 m/min. Here thickness of the fusion line between AZ31B weld and base metal region is 1.65 mm in contrast to 1.28 mm in case of joints obtained at WFS of 3.2 m/min. Excessive wetting and spreading of weld metal over Ti–6Al–4V has resulted in the poor fusion between base metal and weld metal regions of AZ31B alloy. Microstructural analysis of weld regions of both joints shows that the joints obtained at WFS of 3.4 m/min have larger size of secondary phase principates. Elemental analysis of joints obtained at WFS of 3.4 m/min shows the non-uniform distribution of Al at AZ31B weld region and, oxygen has high-er concentration at joint interface. These joints have sustained an ultimate tensile-shear load of 1323.77 N, while the joints obtained at WFS of 3.2 m/min could sustain the load of only 514 N. Fractography of the joints revel that joints obtained at WFS of 3.2 m/min have smaller sized dimples, unform surfaces and a few cavities. WFS 3.4 m/min jointsi fractures zones in-clude the cavities, dimples and, brittle failed regions with tearing ridges owing to complex hexagonal close packed nature of AZ31B metal. This is result of the active basal slip planes and inactive prismatic and pyramidical planes at room temperature.

OPTIMIZATION OF PET BOTTLE RECYCLING FOR FILAMENT PRODUCTION: A COMPREHENSIVE STUDY ON 3D PRINTING PARAMETERS AND MATERIAL PROPERTIES

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The abstract describes the assembly process of a device for recycling PET bottles into filament, outlining the adhesion problems and 3D printer parameter settings that arose during the 3D printing of parts for the setup, along with proposed solutions to these issues. A prototype setup for producing filament from PET bottles has been developed and manufactured, which can also be used as an element of plastic waste recycling technology. During the 3D printing of setup parts from PLA plastic, 3D printing problems were identified and analyzed. Recommendations are provided for eliminating these shortcomings by optimizing printing speed, temperature, infill density, and layer thickness parameters. The structure of the experimental setup and methods for processing the obtained data for calorimetric, thermomechanical, and mechanical analysis are described. The results of measurements of PET characteristics before and after recycling into filament were studied. The temperatures of the main transitions of PET filament from glassy to highly elastic and viscous states were determined. From the mechanical analysis, the modulus of elasticity, yield strength, and fracture point were analyzed. A comparative analysis of PET before and after recycling into filament was conducted. Mechanical tests showed that the stress and strain yield of PET filament are lower than those of PET plastic before recycling. The Young's modulus and tensile strength for PET filament are the same within the margin of error, but the elongation at break is almost half of PET plastic before recycling. Using DSC and TMA analysis methods, it was established that the glass transition, melting, and crystallization temperatures, the enthalpies of melting and crystallization, the coefficient of volumetric expansion, and the degree of crystallinity for PET plastic before recycling into filament and the filament itself do not differ within the margin of error.

CALCULATION PREDICTION OF WELDING DISTORTIONS OF LARGE-SIZED CYLINDRICAL STRUCTURES

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Welding technology is widely used to joint large-sized cylindrical structures for power industry, transport engineering and others. In order to predict the accuracy, strength and durability of such welded structures, determination of residual stresses and deformations is required. The most difficult problem is the prediction of overall distortions of structures with a large number of welded joints. A mathematical model and a calculation algorithm have been developed based on the approximate inherent strain method within the theory of elasticity, which makes it possible to quickly predict the overall distortions of a large-sized cylindrical structure with a large number of welded joints. Verification of the mathematical model for predicting residual deformations during welding of circumferential and longitudinal joints of a large-sized cylindrical vessel made of aluminum alloy was carried out. The developed mathematical models and calculation algorithms can be effectively used for operational prediction of the distortions and stress state during assembly welding of large-sized cylindrical structures. The results of mathematical modeling of general distortions of the a large-sized cylindrical vessel (diameter 3200 mm, total length 11 m, wall thickness 10 mm) made of aluminum alloy when using the Friction Stir Welding process and traditional Arc welding are compared.

BIOCOMPATIBLE Zr-Nb ALLOY COATINGS PRODUCED BY MICROPLASMA SPRAYING ON THE SURFACE OF IMPLANTS

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After implantation, the implant surface is the first to interact with the surrounding living tissue, so coating the implant surface is an important technological technique to impart chemical and physical properties to it that contribute to the overall increase in the biocompatibility of the entire implanted device. It is proposed to increase the titanium alloy implants biocompatibility by microplasma spraying on their surface of Zr–Nb alloy coatings, which has higher corrosion resistance and no adverse allergic reactions of surrounding tissues compared to Grade 5 alloy.

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POLYLACTIDE/BISMUTH FERRITE 0-3 TYPE POLYMER COMPOSITES AS FLEXIBLE PIEZOELECTRIC NANOGENERATORS

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This work studies the impact of BiFeO₃ (BFO) piezoelectric nanoparticles on the performance of 0-3 polymer (PLA) composites. The effect of synthesis and concentration of BFO nanoparticles on the filler dispersion, structure, dielectric properties and piezoelectric response of composite thin films was investigated. Nanocomposites with 15 and 20 wt.% BFO for air steam pressure actuation (11.54 bar) showed good energy conversion efficiency of 59.34 and 57.27 W/cm², respectively.

APPLICATION OF ADDITIVE ELECTRON-BEAM TECHNOLOGIES

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Innovative technologies of layer-by-layer production of products by the method of rapid prototyping open new opportunities for the production of parts of a given shape and structure with properties predicted in advance. The processes of manufacturing products by this method using an electron beam have shown great prospects for their application for the production of a wide range of parts and assemblies. This approach distinguishes the rapid transition to the production of three-dimensional products directly from the automated design system with the possibility of using a wide range of metals and alloys, including refractory and chemically active ones.

All currently existing industrial samples of similar equipment belong to foreign companies. There is no mass-produced domestic equipment. The technologies and equipment being created are focused on the needs of Ukrainian enterprises. For production, it is planned to use inexpensive domestic raw materials necessary for the manufacturer. This approach provides an opportunity to ensure the production of parts and assemblies based on the needs of the customer and in close contact with him. The technologies being developed will allow to reduce the terms of introduction into production of new types of products, to expand their assortment, as well as to manufacture fundamentally new types of products, the production of which is impossible without the use of 3D printing methods.

It is urgent to create equipment and software for it in Ukraine for the implementation of additive electron beam production, free from imported raw materials, oriented for implementation at enterprises of the aerospace industry and turbine construction: Motor Sich JSC, Pivdenne Design Office, Zorya-Mashproekt SE, LUTSK REPAIR PLANT MOTOR LLC.

In the conditions of martial law in Ukraine, it is urgent to provide the medical industry with reliable, competitive domestic implants and prostheses. Additive methods are the most effective for the production of individual medical products.

On the basis of industrial equipment for electron beam welding, experimental equipment for reproduction of additive processes has been created, and a hardware and software platform for controlling additive production has been developed. Prospective domestic metal powder materials suitable for additive manufacturing were studied. According to the additive technology, prototypes were manufactured and tested, and rational technological modes of surfacing were invented. Methods of designing products have been created. Printing of experimental samples for the needs of aircraft engine construction was carried out. Designed and manufactured individual medical implants.

EFFECT OF Ti/Cu AND Ti/Ni MULTILAYER FOILS ON MICROSTRUCTURE AND MECHANICAL PROPERTIES OF DIFFUSION BONDED Ti6AI4V ALLOY JOINTS

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Ti6Al4V alloy is the most popular among titanium alloys of $\alpha+\beta$ class. Due to its low specific weight, high corrosion resistance and specific strength, Ti6Al4V alloy is widely used in the aerospace, automotive, shipbuilding, etc. industries as the basis of structural elements. However, creating new modern large-size constructions requires the bonding of their elements, including thin-walled and complex shapes. Traditional welding and brazing of Ti6Al4V titanium alloy is performed at high temperatures and is accompanied by structural transformations and grain growth, which leads to a decrease in material strength and the formation of residual stresses in the joint. The use of multilayer interlayers, in which the diffusion processes of mixing of components occur at an abnormally high rate during heating, allows to reduce the temperature of the joint formation process. Taking into account that Ti6Al4V alloy joining is recommended to be carried out at a temperature below the temperature of $\alpha \leftrightarrow \beta$ transformation, the regularities of Ti6Al4V alloy joining formation using multilayer Ti/Cu and Ti/Ni foils of eutectic composition with melting point 890–950 °C, obtained by electron beam deposition in vacuum, have been studied. The bonding of the Ti6Al4V alloy was carried out in a vacuum brazing furnace at temperatures of 920 and 950 °C with a bonding time of 60 min under compressive pressure of 70 kPa. The microstructure and mechanical properties of the joints were analyzed using scanning electron microscopy and by determining the shear and tensile strength. It is established that

the microstructure and phase composition of the joint is determined by the character of the reaction interaction between the components of the multilayer foil during heating, temperature and melting interval of the foil. It is shown that the heat released by exothermic reaction between multilayer reactants during heating and the formation of pores in the foil affects the diffusivity of components and microstructure of the joint. The formation of a layer of Ti_2Cu and TiCu intermetallics in the joint causes a decrease in the mechanical properties, and the destruction of the joint occurs in the area of the intermetallic layer. When foil Ti/Ni is used, the formation of a dispersed Widmanstätten structure with a nickel content of ~ 4 at.% provide the joint strength at the level of the Ti6A14V alloy.

APPLICATION OF CuSi₃ FOR JOINING OF ELEMENTS OF ARTPIECES WITH TIG BRAZE WELDING

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Due to the peculiarities of the design of art structures, the configuration and mutual location of the joints of their elements and the choice of base materials, the application of arc welding technologies is limited. TIG brazing with CuSi₃ filler wire has advantages in the production of art structures, namely lower heat input and better stress-strain state. The joints show good values of tensile strength and toughness. The formation of systematic defects depends mainly on the brazing technique.

FATIGUE BEHAVIOR OF THIN SHIT JOINTS OF MA2-1M MAGNESIUM ALLOY PRODUCED BY TUNGSTEN INERT GAS AND FRICTION STIR WELDING

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This study evaluates the fatigue behavior and mechanical properties of MA2-1M magnesium alloy joints welded by Tungsten Inert Gas (TIG) and Friction Stir Welding (FSW). TIG-welded joints showed higher tensile strength (up to 267 MPa), while FSW joints provided superior fatigue performance with only a 7 % reduction in fatigue strength at 10⁶ cycles. FSW also produced more uniform welds with fewer defects. FSW is recommended for applications requiring durability under cyclic loading.

GROWTH OF TUNGSTEN SINGLE CRYSTALS IN THE FORM OF BODIES OF ROTATION USING 3D PLASMA-INDUCTION TECHNOLOGY

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3D technology of additive growth of refractory metal single crystals by plasma-arc heating is developed. The technology of growing single-crystal bodies of rotation up to 85 mm in diameter has been worked out. Technological equipment allows both solid cylindrical and hollow ingot growth (tubular billet, crucible). The technology of producing of hollow ingots with a wall thickness of 19–23 mm has been developed. Studies of the ingot structure have shown heredity and preservation of the single-crystal structure from the seed crystal.

APPLYING NEURAL NETWORK TECHNOLOGIES FOR QUALITY CONTROL IN ROBOTIC ADDITIVE MANUFACTURING

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3D printing technology is currently actively used to manufacture parts in various industries. The production of metal parts using additive deposition may be accompanied by the appearance of surface defects in the deposited layers, namely pores and cracks. Using a robotic complex based on an anthropomorphic robot with an integrated machine vision system increases the surfacing process's quality and productivity. The hardware component of the machine vision system consists of a high-speed GigE camera and a controller. The software uses the YOLO-NAS neural network architecture to detect and classify defects automatically after the completion of the deposition process of the corresponding layer. The quantitative characteristics of the quality of recognition and classification using a trained neural network model are given. It is recommended that anthropomorphic robots and machine vision systems based on neural network technologies be used for manufacturing parts for a responsible purpose using WAAM technology.

DEVELOPMENT OF TECHNOLOGY FOR HEAT TREATMENT OF WELDED JOINTS OF RAILWAY RAILS

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Heat treatment of welded joints is used to eliminate the negative effects of welding. The E.O. Paton Electric Welding Institute has developed technology and equipment for heat treatment of welded joints of railway rails made by resistance butt welding. The heat treatment technology involves local heating of the metal in the welded joints by induction with high-frequency currents and subsequent hardening of the rail running surface with compressed air. A low temperature difference between the surface and deep layers of rail metal is achieved by reducing the current frequency to 2.4 kHz. Heating devices of the same design, including matching transformers, inductors and cooling elements, are used to heat the metal in the welded joints on the side surfaces of the rails. The inducting wires of the inductors follow the shape of the bend of the rail side surfaces above the head, neck, feather and sole parts. Air gaps are reduced over the rail head and sole, increased over the neck, and significantly increased over the rail feathers. This prevents the rail elements made of a relatively thin metal layer from overheating. To achieve optimal distribution of the transmitted power to rail elements with different metal weights, U-shaped tape magnetic circuits are installed along the rail perimeter. These features of the heat treatment technology and the design of the heating devices ensure an even distribution of the temperature field in the rail elements and no overheating of the rail feathers. In particular, the heating rate of the metal of welded joints of R65 rails to the temperature of magnetic transformation reaches 7.5 °C/s, the time for heating the metal in the center of the head to a temperature of 900 °C is 180 s, the temperature difference between the rolling surface and the center of the head does not exceed 50 °C, and the total heat treatment time, taking into account the hardening time, is within 400 s. The width of the heat-affected zone after heat treatment depends on the width of the inducting wires of the inductors. In this case, it is 45-50 mm, which exceeds its value after resistance butt welding.

FATIGUE PERFORMANCE AND STRUCTURE OF INCONEL 718 ALLOY OBTAINED VIA SELECTIVE LASER MELTING

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The selective laser melting (SLM) is an additive manufacturing process applied to fabricate the metal parts owing to the melting of the metal powder in a layer-by-layer approach.

Results of low cycle fatigue (LCF) testing, fatigue limits definition, investigation of microstructure and fractures of specimens, which was obtain by selective laser melting (SLM) process of the Inconel 718 alloy powders has been carried out in present article. For comparative studies, samples from traditional hot-rolled bars are tested.

The results indicate that heat-treatment imparts polyhedric structure to the hot rolled materials and leads to clear layer-by-layer fusion areas approximately $100 \mu m$ in size. After heat-treatment, the alloy is strengthened with an intermetallic Nb-based phase. A lamellar-phase was also designated in the microstructure.

It was determined fatigue limits for SLM-material and hot-rolled bars made from Inconel 718 alloy, which shows similar results.

Upon the LCF-tests, istrain — number of cycles to failure logarithmic curves were plotted to determine, with adequate reliability, the reasonable level of stresses to allow the predetermined number of cycles to failure for both considered sample manufacturing technologies.

Results of the fractures investigation after LCF-testing at 550° shows that during the cyclic elastoplastic deformation at elevated temperature multicentricity of crack initiations zones observes. Mainly fixed a viscous pattern of fracture with a fatigue grooves presence, which size increases in process of crack advance to the zone of fracture area.

ELECTROSLAG REMELTING OF VARIABLE CROSS-SECTION ELECTRODES USING A TWO-CIRCUIT SCHEME

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The paper considers the formation of a liquid metal bath during electroslag remelting using a two-circuit scheme of variable-section electrodes with a change in the filling factor from 0.69 to 0.2, which imitate the recycling of spent cold rolls and rollers of continuous casting machines. The shape of the ingot metal bath after ESR of variable cross-section electrodes was studied on experimental melts and the possibility of producing an ingot with a constant profile of the liquid metal bath along its cross section was established. Mathematical modeling of the current distribution in the slag bath during ESR of variable cross-section electrodes was carried out and the operating parameters of the remelting process were determined to produce an ingot with a constant profile of the liquid metal bath along its cross section.

CHANGES IN THE STRUCTURE AND PROPERTIES OF HIGH CHROMIUM CAST IRON SOLDERED WITH CARBIDE ENCAPSULATION IN A CHARGE OF POWDERED WIRE

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On the basis of the conducted experiments, the effectiveness of the introduction of chromium carbide from the powder wire charge in the form of dispersed particles, previously covered with a protective layer of plastic, during arc hardfacing has been proven. To achieve this powder wire of the brand VELTEK-N630-O was used. The conducted metallographic analysis revealed a difference in the shape, amount and distribution of carbides in the cross-section of the deposited layers of alloys, which are close in composition to high-chromium white cast iron. An increased proportion of carbides in the upper part of the formed layers and a smaller number of cracks is considered a positive fact, which should contribute to resistance during their wear. For the final determination of the type of carbides and matrix in the structure of the deposited layers, microhardness measurements were performed. The addition of plastic to the charge caused a decrease in the initial hardness of the metal of the applied layer — *HB* 483 against *HB* 510 for the standard wire (two-pass surfacing). However, the wear test according to the "metal-metal" scheme recorded a decrease in the mass loss of the samples welded with the experimental wire: 0.158 g against 0.208 g in 12 h rolling friction under a load of 1.0–1.5 kN.

MECHANICAL AND DISSIPATIVE PROPERTIES OF Al-Cr-Fe COATINGS BASED ON APPROXIMANT PHASES

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Al–Cr–Fe coatings based on approximant phases are considered to be promising for the use as hard and highly damping coatings on blades of gas-turbine engines. The mechanical behavior and dissipative properties of vacuum Al–Cr–Fe coatings based on gamma-brass cubic Al₉(Cr, Fe)₄ and orthorhombic O1/O–AlCrFe approximant phases were comprehensively analyzed. Differences in the mechanical behavior of materials based on gamma-brass phase and approximant orthorhombic phases are found. Dependences of the dissipative properties of heterogeneous Al–Cr–Fe coatings with rigid and soft matrices containing orthorhombic approximant phases are discussed.

APPROVAL OF THE INDUCTION PRESSURE WELDING PROCESS OF HIGH CARBON STEEL

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Welded joints obtained using induction welding are studied in many leading scientific laboratories. The use of activating substances in the process of pressure induction welding is one of the main factors that positively affects the formation of the welded joint, which occurs in the solid phase. Activating substances introduced into the weld zone, their composition and melting temperature, electrochemical and thermochemical processes that occur in the weld zone, as well as thermal deformation processes under deposition conditions determine the quality of the resulting welded joint. It is considered a promising direction of research into welding processes of the same structural elements of welded structures in the case of the use of related grades of steel produced by different manufacturers according to different technological processes, for example, there are rebars, pipes of different manufacturers, rolled metal of a complex profile — rails, etc. Such features affect the manufacturability of welding in different ways.

The effect of PAN-3 solder, as the main component of the activating substance in the process of pressure induction welding on some grades of steel, in particular St20, was previously investigated. The effect of 18XFC solder produced in France on obtaining a welded joint of carbon steels during pressure induction welding was also determined. The testing took place on model samples made of carbon steel, in particular rail — K76F in the process of induction pressure welding in the joint with the use of an activating substance with solder 18XFC as a component of the activating substance. According to the results of metallographic studies, solder residues in the form of eutectics and quenching structures were not detected in the welded joints of the obtained model samples. The thickness of the weld was $400-485 \, \mu m$. This indicates the perspective of using activating substances in induction pressure welding.

MECHANICAL PROPERTIES OF WELDED JOINTS OF MEDIUM CARBON ALLOYED STEELS HEATED TO TEMPERATURES FROM 250 TO 1200 °C

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It is known that during welding two characteristic areas are formed — hardening and tempering. The depth of these areas reaches 2.5 and 8 mm, respectively. Depending on the steel grade, the depth and value of hardness of these areas change. The transition from the first to the second occurs in the area of incomplete recrystallization, which in structure is a mixture of martensite, ferrite and carbides. The structure of the tempering area consists of bainite, trostite and gradually, with distance from the weld, passes into the structure of tempered martensite without external

differences from the base metal, but with lower hardness values than the base metal. The total width of the de-hard-ened area of the heat-affected zone (HAZ), consisting of areas of incomplete recrystallization and tempering, for welded joints with a thickness of 6–20 mm and depends on the linear energy of welding and can vary in the range of 3–8 mm. The work provides for the first time structured information on the features of the thermal welding cycle and its influence on the mechanical properties in the HAZ metal in the area heated to temperatures from 250 to 1200 °C.

STRUCTURE MODIFICATION OF WELDS METAL HSLA STEELS BY NANOOXIDE PARTICLES

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One of the common methods of increasing the viscosity of weld metal, especially at negative test temperatures, without reducing the level of their strength, is the process of modifying the weld metal. The process of metal modification has long been used in the production of steel castings, while this method has not been widely used in welding or additive manufacturing in order to influence the set of mechanical properties of the metal. This is due to a number of factors, and above all, the difficulties that arise when introducing modifiers into a liquid welding pool.

Recently, a number of publications have appeared in the literature, which show the feasibility of inoculating nanosized particles of refractory compounds into the metal melt to modify the weld metal in the process of crystallization and microstructure formation.

One of the effective mechanisms for modifying the structure is related to the increase in the centers of crystallization of the metal melt through the use of flux-cored wires of different fillings during welding. There were works that showed the influence of nanosized inoculators on the properties of the metal of welds.

The purpose of this work was to investigate the effect of nano-sized refractory oxide-type particles on the formation of the microstructure and mechanical properties of the weld metal of HSLA steels.

Peculiarities of the formation of the metal microstructure of welds of low-alloy steels with the inoculation of nano-sized particles of refractory oxides Al_2O_3 , TiO_2 , MgO, ZrO_2 into the welding bath were investigated. It is shown that the inoculation of oxides with a low level of mismatch to the α -Fe lattice and increased wetting with liquid iron (MgO, ZrO_2) into the welding bath contributes to the growth of dendrites that are formed during melt crystallization. Modification of the metal with nanodisperse oxides MgO, ZrO_2 helps to reduce the hardness of polygonal ferrite and increase the content of lower bainite in the microstructure of the seams, increasing the resistance of the metal of the seams against brittle fracture. Metal modification with Al_2O_3 , TiO_2 oxides contributes to increasing the hardness of polygonal ferrite and increasing the content of upper bainite in the microstructure of welds, increasing of welds metal strength of low-alloy steels.

THE EFFECT OF HEAT TREATMENT ON Ti–Zr–Nb ALLOY MULTILAYER JOINTS, OBTAINED BY THE WAAM WITH FILLER CORED WIRE

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The multilayer sample based on titanium alloy of the Ti–Zr–Nb system was obtained by the WAAM (TIG method) with filler metal-powder wire, the basis of which is powder obtained by the Hydrogenation–DeHydrogenation method. As a result, a 9-layer sample was obtained. Its microhardness is at the level of 4200–5000 MPa, Young's modulus is 114 GPa. The effect of various types of heat treatment (vacuum annealing, quenching, quenching with aging) on the microstructure and microhardness of the obtained metal was studied.

NEW METHOD FOR IMPROVING PHYSICAL HOMOGENEITY OF STEEL INGOTS

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The problem of physical homogeneity of ingots has been a subject of study for several centuries and remains unresolved. The ingots have axial porosity and cavities that form during the metal solidification process. A new method for controlling the ingot crystallization process by applying a combined external effect is proposed that of heating the top of the ingot, combined with stirring the liquid metal in the inner middle part of the ingot during its solidification. The results from physical and mathematical modeling confirm the ability of increasing the physical homogeneity of ingots. Research of ingots, which had a height-to-diameter ratio of 2.1–2.5 and a taper of 3–5 %, showed that the ingots were free of gross defects of shrinkage origin, and they had reduced axial porosity. The proposed method may be a promising one for increasing the physical homogeneity of large steel ingots.

EVOLUTION OF LIQUID-PHASE METHODS FOR GROWING MOLYBDENUM SINGLE CRYSTALS

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The evolution of liquid-phase methods for growing molybdenum single crystals is analyzed. It is shown that the methods for growing crystals with a single heating source cannot solve the problem of producing industrial-sized crystals. Super-large molybdenum crystals of various configurations can be produced using the combined plasma induction method. This method is already used for growing single-crystal ingots, as well as single-crystal plates. The monocrystalline quality of the ingots and the preservation of the orientations of the selected crystallographic axes were confirmed by the X-ray method according to Laue. Single crystals of refractory metals with a given orientation have prospects for application in the power optics of high-power lasers.

FORMATION OF MICROSTRUCTURE AND MECHANICAL PROPERTIES ON INNER CYLINDRICAL SURFACES BY PLASMA NITRIDING

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The plasma nitriding technology of the inner cylindrical steel surfaces in the mode of anomalous glow discharge according to the hollow cathode-perforated tube anode scheme has been developed.

The use of a hollow perforated anode, discrete diffusion coatings with different chemical and phase compositions were obtained. The maximum nitrogen concentration in areas opposite the holes in the anode.

The structure of the nitrided surface is layered and consists of three zones: nitride, transition and diffusion. The surface layers have increased hardness, as determined by the results of the *HRB* and scratch test.

THE PHOSPHORUS INFLUENCE ON PROPERTIES OF COPPER ALLOYS USED FOR CCM CRYSTALLISERS

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The paper provides a comprehensive assessment of the possibility of obtaining high-quality copper plates for CCBC crystallizers based on domestic technologies and equipment using refined copper. Special attention was paid to the need to optimize the chemical composition of the copper alloy within a narrower range of chemical element values. The analysis of the research shows that currently used copper alloys for CCM crystallizer manufacturing have a wide range of fluctuations in the main operational properties, namely thermal conductivity (260–390W/(m·K)) and solidification temperature (250–700 °C). Most of the alloys used have narrower fluctuation limits for acceptable values, constituting 340–390 W/(m·K) for thermal conductivity and 300–370 °C for solidification temperature, significantly depending on the impurity content in the copper alloy. It should be assumed that the rational phosphorus content in the alloy is in the range of 40–120 ppm. In this case, the thermal conductivity of the alloy will be in the range of 370–400 W/(m·K), the solidification temperature will be 410–440 °C, and the recrystallization start temperature will be 370–400 °C. As a result of the conducted research, optimal limits of phosphorus content in fire-refined copper were established, ensuring the level of its physico-mechanical properties not lower than the indicators characteristic of alloys obtained from cathode copper.

EFFECT OF HEAT TREATMENT ON THE STRUCTURE OF THE Fe–28Mn–12Al–0.9Si–1.35C ALLOY, ADDITIONALLY DOPPED BY Ni 3.3, Cr 1, V 0.15 (wt.%)

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Microstructure of the novel high-strength steel Fe–28Mn–12Al–0.9Si–1.35C after additional alloying and thermal treatment was investigated. Nickel and chrome in quantity of 3.3 and 1.0 wt.% respectively were added to the basic alloy to obtain less primary ferrite and to ensure austenite alloying rate. Vanadium was added to refine structure and to elevate mechanical properties. All three alloys were investigated in four states: as-cast, annealed, quenched and aged after quenching.

PROPERTIES OF BIODEGRADABLE POLYMER THIN FILMS BASED ON PLLA

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The mechanical and piezoelectric properties of PLLA-based films with a 100–150 nm thickness, prepared by the hot-compaction method, were studied. The obtained experimental parameters such as Young's modulus 2.9 GPa, tensile strength 39 MPa, elongation at break 1.8 %, piezoelectric coefficient $d_{33} = 3-5$ pC/N provide an opportunity for medical applications, like cartilage implants and tissue engineering.

A STUDY ON STRUCTURE AND DISTRIBUTION OF THE ALLOYING ELEMENTS THROUGHOUT THE MATERIEL DURING LASER CLADDING ON A THIN-SHEET BASE

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When working with thin-walled products, the issue of surfacing structural components onto a thin-walled work-piece using laser radiation arose. However, in these conditions, the use of laser surfacing leads to a very high risk of deformation and melting of the workpiece. The production of thin-walled elements, as well as elements on a thin-walled base, remains one of the fastest growing areas of additive manufacturing technologies. It is known that laser power and energy density are important factors affecting the quality of parts manufactured using this technology. Therefore, to establish the degree of influence of laser surfacing parameters on the structure for-mation of three-dimensional structural elements, it was decided to conduct a series of experi-mental studies to determine the structure of the material formed by laser surfacing on a thin-walled base as well as distribution of the alloying elements throughout the material of the mate-rial formed using this technology.

The study was carried out using scanning electron microscopy and spectral analysis technolo-gies, where the samples were examined in different areas of deposited metal, heat-affected zone and base metal. The structure was assessed using macroscopic and microscopic examinations. The possible presence of cracks, delaminations, and voids was also assessed.

The study was carried out using a TescanVega3 microscope, and chemical analyses were performed using a Bruker spectroscope. The obtained photos were taken in BSE and SE modes and the quality of the image was doubled (original 512×512, output 1024×1024).

Over the course of the study, multiple areas of the samples were analyzed. As a result, it was es-tablished that:

- a semi-uniform dendritic structure is observed at the most of the depth of the clad sam-ples, with wider dendritic structures at the surface layers;
- near the weld line, at the edge of the heat-affected zone, a more chaotic structure is ob-served at all laser power layers;
- beyond the heat-affected zone, the structure of the base metal remains mostly unchanged;
- at the surface layers, the directions of dendrite clusters is chaotic, coupled with visible clustering of alloying elements;
- the dispersion of the alloying elements appears to be reliant on the laser power level, as the samples, produced at the lower laser power (1.5–2.0 kW) present a more uniform distribution of alloying elements throughout the structure:
- the alloying elements of the base metal are mostly observed near the heat-affected zone.

RECENT OBSERVATION OF HYDROGEN ASSISTED COLD CRACKING OF HIGH STRENGTH STEEL WELDMENTS

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The hydrogen assisted cold cracking (HACC) of high strength steel weldments creates the serious technological problems. The physical model developed by PEWI was used as the basis of the mechanism of HACC formation. The model is based on advanced ideas of metal physics about a mechanism of steel cleavage fracture. The key elements of the model are dislocation structure evolution and microcrack behavior. The dislocations have a particular function because their moving is both a main mechanism of the plastic strain and an efficient mechanism of hydrogen transportation in the metal.

DEVELOPMENT OF POLY (3-HYDROXYBUTYRATE) BASED BIOCOMPOSITES WITH GRAPHENE FILLERS OF VARIOUS STRUCTURE FOR PIEZORESITIVE SENSORS

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In connection with the rapid scientific and technical progress and the massive use of plastic in everyday life, in particular electronics, a number of environmental problems arise. This is what creates the relevance of this topic and the solution of a number of environmental and economic problems, the creation and replacement of eco-friendly electronics. Conducting electroactive polymer composites have also been investigated for various potential applications which include biological, biomedical, flexible electrodes, display devices, biosensors, and cells for tissue engineering. These biopolymer composites generally consist of nanoscale metal nanoparticles and carbon-based nanofillers such as carbon nanotubes, graphene, graphene oxide (GO), etc., dispersed into the polymer matrix. The physical and chemical properties of these fillers and their interactions with polymers have a significant effect on the microstructure and the final properties of nanocomposites.

Natural poly(3-hydroxybutyrate) (PHB) was chosen as the base material, and graphene nanomaterials of different structures, including raw and oxidized multi-walled carbon nanotubes and graphene nanoplatelets, were used as conductive fillers. The fabrication process involved a simple solvent casting procedure, where the conductive graphene fillers were incorporated into the biopolymer matrix without additional steps. Due to the high crystallinity and poor film-forming ability of PHB, a commercial PHB atactive was added as a modifier to improve the film quality. Through optimization, a PHB/PHBAT weight ratio of 70:30 was identified as the most promising composition to achieve composite films with desirable mechanical properties. The influence of graphene material structure and concentration on the crystallinity, thermal, mechanical, electrical, and piezoresistive properties of the composites was investigated. The results demonstrated that the PHB/PHBAT matrix filled with graphene materials has the potential to fully replace conventional structural composite materials, such as polypropylene, with biomaterials, making them suitable for a wide range of applications.

Eco-electronics is a new step in the ecological future with an economic direction, because these are renewable materials, which are an alternative substitute for mined materials, which are not renewable resources and this is another reason for the future economic problem.

The sensors offered by us are separate electrical devices, and can also be elements of electrical circuits and devices. By changing the physical and chemical properties of materials, we can also change the properties of the final devices depending on the purpose and final result.

ENERGY-SAVING TECHNOLOGIES IN EAF WITH A "DEEP" BATH

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In the context of EU Green Deal, the technologies of hydrogen-based direct reduction of iron and electric arc furnace (EAF) — based steelmaking appear to be the most acceptable in the nearest future. By means of numerical modeling, an assessment of energy-efficient EAF solutions based on lowering of liquid bath shape factor (ratio of diameter to depth at fixed heat mass) from traditional 4.5–5.5 to 2.0–2.5 is given. A "deep" bath provides increasing of argon purging mixing power by a few times. It promotes reducing arc-heating time of the bath to tapping temperature and additions melting time by 12–16 %; lowering of iron losses by evaporation in arc spots, nitrogen pick-up and NOx formation by 10–12 %; increasing of sulfur removal rate up to 60 %. In a DC EAF electromagnetic mixing power in a ideepî bath increases up to 8 times depending on bottom electrode features. A "deep" bath gives a possibility to increase oxygen blowing flowrate and decarburization rate up to 1.5 times without negative impact of the jet on refractories consumption. Due to reduction of open radiationg surface, the "deep" bath provides reduction of heat losses in water-cooled panels up to 35–45 %, especially for innovative continuous "flat bath" process. Overall energy savings in the EAF when using a "deep" bath are expected to be at least 15 %.

CURRENT STATE OF TECHNOLOGIES AND PROSPECTS OF DEVELOPMENT IN THE FIELD OF LIVE TISSUE WELDING WITH HIGH FREQUENCY CURRENTS

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The results of the research of the PWI in the field of high-frequency welding of biological tissues for their connection, coagulation and cutting are presented. The authors share their experience in creating specialized equipment, tools and algorithms for the implementation of these processes.

In laboratory and clinical conditions, complex studies of the behavior of various types of such tissues under the influence of high-frequency current were carried out on biosimulators and removed animal organs, new original process algorithms were proposed and tested, which ensure high quality of the obtained connections and shorten the recovery time of operated tissues.

The use of developed technologies and equipment in practical surgery ensures: bloodless, fast, low-traumatic for the patient surgical interventions, reliable hemostasis without the use of suture materials; reduction of blood loss by more than 50 %; reducing the duration of operations by 20–50 %; rapid rehabilitation of patients after surgery.

Prospects for further development of technologies and equipment for high-frequency welding in medicine and veterinary medicine are considered.

Commercial aspect. The EKVZ-300 model of the "Patonmed" brand, for which a Registration Certificate has been obtained, is being produced in series. New models of HF generators are developed to order, or specific modifications of existing equipment are created.

We are looking for customers and partners for contract development of equipment (HF generators, specialized tools).

CORRELATION-DETERMENIZED METHOD FOR CREATION A PRECISION 2D X-RAY SCANNER BASED ON HAMAMATSU MINI-SENSOR

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For non-destructive testing of objects, an X-ray detector has been created at the E.O. Paton Electric Welding Institute of the NAS of Ukraine, which based on a digital dental mini-sensor S10811-11 (Hamamatsu Photonics, Japan). 2D scanning with such a sensor allows you to multiply the working testing area. Adjacent fragments of digital X-ray images obtained during scanning saved and stitched into a full-format digital image by software.

PHYSICAL AND MECHANICAL PROPERTIES OF REFINED COPPER AS A FUNCTIONAL MATERIAL FOR WORKING WALLS OF CONTINUOUS CASTING MOLDS

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The main functional component of continuous casting machines for metals and alloys is the mold, which ensures the formation of the geometric shape and solid crust of the billet. The working walls of molds for casting steel and copper are usually made of cathode copper M1 or high-purity alloyed copper. The correct choice of mold wall material and the optimization of its structural elements can significantly enhance the operational life of the mold.

This paper presents the results of a study on the physical and mechanical properties of plates made from fire-refined copper. The feasibility of using them as a multifunctional material for the working walls of molds is substantiated. The comprehensive analysis of the properties of refined copper included the following determinations: electrical resistance as an indirect indicator of thermal conductivity; relative elongation of samples during tensile testing to failure as an indicator of plasticity; measurement of the number of revolutions during torsion testing to failure as an indicator of thermal cycling; recording the temperature at the onset of recrystallization as an indicator of thermal stability; material's ability to strain hardening; material's resistance to oxidation (mass loss during heating in an oxidizing atmosphere) to adjust hot rolling parameters.

The conducted research has shown that fire-refined copper is a promising functional material and can be considered as a base material for manufacturing plates for the working walls of rectangular molds used in continuous metal casting.

ALUMINOTHERMAL RECOVERY OF VANADIUM-CONTAINING WASTE IN ELECTROSLAG MELTING

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Given the growing demand for ferrovanadium, a certain shortage of it in Ukraine, and the growing amount of vanadium-containing industrial waste, it is appropriate to study the recovery of vanadium from them in the most economically feasible way. The process of producing ferrovanadium from chemically enriched vanadium-containing waste, where secondary aluminum is used as a reducing agent and small metal waste from various industries is used as a filler. The electro-alumina reduction process takes place in a single stage, under a slag layer, and is completely controllable. The process parameters as well as the chemical composition of the metal and slag can be controlled in a wide range, depending on the requirements for the final product. The investment component in equipment for this process is relatively low. The technology ensures the extraction of vanadium into metal up to 85–90 %, high quality of the product with a vanadium content of from 40 to 80 % and the possibility of implementing waste-free production.

THERMAL BARRIER COATINGS PRODUCED BY THERMAL SPRAYING AND CONTAINING MAX PHASE Cr, AIC

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Two-layer thermal barrier coatings, consisting of a bond coat produced by air plasma and HVOF spraying methods and containing the MAX phase Cr_2AlC , and a ceramic layer of yttria-stabilized zirconia produced by air plasma spraying, have been developed. The developed coatings are resistant to thermal shock under conditions of heating by a gas burner flame and cooling by water, which exceeds the resistance of thermal sprayed two-layer and five-layer gradient coatings of the NiCrAlY + ZrO_2 - Y_2O_3 system by 2.8 and 1.3 times, respectively.

DIFFUSION FORMATION OF Fe(Co)-Pt FERROMAGNETIC THIN FILMS

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Formation of magnetic thin films for nanoelectronics and data storage applications via thermally-induced phase transitions in multilayer stacks is a promising technology-relevant approach. In particular, Fe(Co)–Pt-based films, which could be formed in the such way, are promising materials due to their excellent magnetic properties ñ high magnetic anisotropy and coercivity, tunable magnetization and good corrosion resistance. Impact of treatment parameters and alloying on structural and magnetic properties of Fe(Co)–Pt-based multilayer stacks will be discussed.

GRAIN REFINEMENT AS A METHOD OF CONTROLLING THE FORMATION OF HOT CRACKS DURING LASER WELDING OF STAINLESS STEEL

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When welding austenitic corrosion-resistant steels, one of the characteristic defects is the formation of hot cracks. Therefore, several strategies have been developed to control the grain structure and prevent cracking during crystallization, as described below.

Grain refinement. Significant grinding of metal grains in the weld zone is achieved by stimulating their nucleation during crystallization. The addition of elements such as titanium and boron helps to change large columnar grains, which cause low critical deformation and the formation of crystallization cracks, into more equilibrium and smaller ones.

Additional laser scanning during welding. This method ensures grain refinement compared to welding without laser scanning. Scanning of laser radiation at a frequency of 100 Hz allows to change the distribution of heat input, which in turn provides a change in the crystallization process and leads to the formation of a larger molten pool, and therefore reduces the tendency to cracking, since the temperature gradient in the crystallization region is reduced, expanding the equilibrium zone in the center of the melting zone.

Vibration during laser welding. An alternative method for grain refinement and prevention of cracking defects during crystallization is vibration. The melt flow in the weld pool changes direction due to ultrasonic vibrations of 4–12 kHz, which causes the liquid to flow downward faster. This results in a pressure gradient in the liquid from the weld pool wall to the inside of the weld pool, which subsequently increases the forced convection of the metal. The intense forced convection and disordered flow of liquid metal create a weld pool with a more consistent temperature distribution.

Laser welding parameters. The rate of local crystallization and temperature gradient during welding are affected by laser power, welding speed, continuous or pulsed mode, preheating, mechanical limitations, etc. Thus, they can affect the grain structure of welded parts.

As the welding speed increases, the tendency to cracking during crystallization of AISI 310 steel is much higher than that of AISI 316 and AISI 304 (at a welding speed of 1 m/min). This is due to the fact that the welded joint of AISI 310 steel forms a fully austenitic structure, while AISI 316 and AISI 304 have a mixed ferrite-austenitic structure. Parameters such as the size of the focus point and its position relative to the surface of the metal being welded, beam quality and laser power during welding affect the dynamics of the melt pool and can be used to control crack formation. X-ray analysis shows that refocusing laser radiation under the metal surface from a depth of 1.4 to 2.1 mm affects the behavior of the melt flow. This is due to a different energy input mechanism, a change in the weld pool geometry and, as a result, different thermally induced stresses and strains that lead to different hot crack patterns.

With the onset of the new tillage season, the tests will continue.

AN ANALYTICAL MATHEMATICAL MODEL FOR MELTING LAYER THICKNESS OF HDPE PIPES AT THERMAL BUTT-FUSION WELDING

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High-density polyethylene pipes (HDPE) are widely utilized in everyday applications, such as water, gas, and sewer mains, and more. The proper melting layer thickness ensures adequate material mixing, interface pressure, defect prevention, and strong mechanical properties. However, in most current studies, determining the melting layer thickness typically relies on numerical model, which leads to significantly low cost-effectiveness. The purpose of this study is to develop an analytical mathematical model for predicting melting layer thickness based on heating time, consisting of two governing equations for heat transfer and a coupling equation at the solid-melting phase

interface with help of the Neumann moving boundary conditions and the latent heat of fusion. The material properties of HDPE pipes are benchmarked from existing literature, with the heat soaking time set to 180 seconds and the heating temperature set to 240 °C. To verify the reliability of the results from the developed analytical mathematical model, a 2D numerical model with dimensions of 50 mm in length and 11.8 mm in width was also built in ANSYS Fluent for comparison at heat soaking times of 30, 60, 90, 120, 150, and 180 seconds. Based on the findings of this study, it can be concluded that the developed analytical mathematical model provides a reliable and accurate approach for predicting the melting layer thickness in HDPE pipes during the heat soaking process. The close alignment of the predictions with those obtained from the numerical model validates its effectiveness. In future research, the developed analytical mathematical model in this study can not only assist in the precise control of welded joint quality in HDPE pipes but also offer insights for studies on high-speed welding of polymers.

ELECTRODE METAL MELTING EFFICIENCY IN THE PROCESS OF PULSE ARC WELDING

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Of all types of arc welding, it is the process of pulse-arc welding in shielding gases with the implementation of the principle "One Pulse - One Drop", which is characterized by a very high productivity of electrode melting. The process takes place without disturbance, the drops of molten metal have a small diameter and are close in size, they are not deformed, they do not boil, and the evaporation of metal from them is extremely small. The E.O. Paton Electric Welding Institute achieved in this process an even greater increase in the efficiency of melting the metal of the electrode, conducting it in reverse polarity and using the proposed special form of the current pulse. At the same time, the current pulse consists of two stages. First follows the first, extended in time and low level of the current pulse. As a result of the action of this pulse, a given volume of the electrode metal is melted. Then comes the second, short-lived and high degree of current pulse, during which a drop of molten metal is transferred in any spatial position of the electrode. Then there is a pause between the supply of the next pair of pulses, during which the arc burning is supported by the base current. Smooth adjustment of the welding current is carried out by the pulse tracking frequency. As a result, the principle of separation of thermal and power effects on the molten metal of the electrode is carried out with the possibility of adjustment by these values in order to ensure the maximum value of the melting coefficient for each electrode material. Thus, the process of pulse-arc welding in shielding gases significantly increases the efficiency of electrode melting at modes with low metal evaporation. An increase in the energy and economic efficiency of the welding arc process is ensured. Application of such pulses in developed in the E.O. Paton Electric Welding Institute power sources allow the welding process to be carried out with minimal evaporation of electrode metal and without its spattering in a bath with molten weld metal for a wide class of structural materials.

WELDED JOINTS FORMATION OF DISSIMILAR NICKEL SUPERALLOYS IN PRESSURE WELDING

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The formation of welded joints of nickel superalloys KhN73MBTYu and VZhL12U in pressure welding methods and the research for ways to prevent the occurrence of cracks were studied. It is known that nickel superalloys have a high tendency to crack formation in fusion welding methods. The technological features of the friction welding (FW) and resistance butt welding (RBW) processes are considered. The study of temperature fields and the formation of the microstructure of welded joints at various stages of the welding process were carried out.

The results of calculation and experimental studies of the temperature change in the contact zone during FW and RBW of KhN73MBTYu alloy and VZhL12U alloy prove that the heating rate in the contact zone of the workpieces at the initial stages of the welding process reaches 103 °C/s. The temperature in the contact zone exceeds the temperature of complete dissolution of the strengthening γ' -phase (solvus temperature) and may exceed the solidus temperature.

The change in the morphology of the strengthening γ' -phase in different zones of the welded joints was studied. It is shown that in the zone of dynamic recrystallization on the side of VZhL12U alloy there is only a small γ' -phase (the average diameter is from 10 to 60 nanometers). The absence of the strengthening γ' -phase in the zone of dynamic recrystallization and its partial dissolution in the thermomechanically-affected zone was found on the side of the KhN73MBTYu alloy. In the heat-affected zone of the studied alloys, a smooth transition to the microstructure of the base metal of both alloys is observed, with a gradual increase in the size and number of particles of the strengthening γ' -phase and its shape approaching the original morphology.

COMPREHENSIVE ANALYSIS OF THE MICROSTRUCTURE AND MECHANICAL PROPERTIES OF DEPOSITED METAL OF NICKEL HIGH-TEMPERATURE ALLOY ZhS32

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During industrial use of the microplasma powder metal deposition (MPD) process at the E.O. Paton Electric Welding Institute, positive experiences with Ni-based superalloy ZhS32 restored edges on aircraft blades were confirmed. A comprehensive analysis, including optical and scanning electron microscopy, and mechanical property studies, aimed to improve the repair area's characteristics and expand the range of parts repairable by MPD. The study examined the ZhS32 alloy's structural states after deposition, aging, and homogenisation heat treatments.

EFFECT OF COOLING RATE ON THE DISTRIBUTION OF ALLOYING ELEMENTS IN δ -FERRITE AND AUSTENITE OF DIFFERENT MORPHOLOGIES IN THE HAZ OF DUPLEX STEEL 2205

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Diffusion of alloying elements of duplex steels in austenite and ferrite affects the formation of the microstructure and the distribution of chemical elements in the material, which affects the mechanical properties, corrosion resistance and other characteristics. Optimum distribution and concentration of alloying elements in each phase help to increase the strength, crack resistance and corrosion resistance of duplex steels. There are almost no studies in the literature on the distribution of alloying elements and nitrogen in the austenite and ferrite phases at cooling rates different from usual, for example, when welding in an aqueous environment. Therefore, the study aimed to determine the distribution of alloying elements and nitrogen in ferrite and austenite of different morphologies and at the δ/γ boundary in the HAZ, depending on the cooling rate during welding.

The article presents the results of determining the distribution of alloying elements in ferrite and austenite in the HAZ microstructure, modelled using the Gleeble-3800 device, during thermal welding cycles inherent in wet underwater welding and air welding. It is shown that with an increase in the cooling rate, the difference in the redistribution of Mo and Cr, as well as N and Ni, between the ferrite and austenite phases decreases. The highest content of these alloying elements is observed at the δ/γ phase boundary.

THE INFLUENCE OF HOLDING TIME ON THE SEAMS STRUCTURE FORMATION BY BRAZING TITANIUM ALLOY TA15

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This work determines the dependence of the seams structure of brazing joints of the titanium alloy TA15 on the holding time by brazing using the Ti–Zr–Cu–Ni brazing filler metal. The technological parameters of the vacuum

hightemperature brazing process are established, which increase both the homogeneity of the structure of brazing seams and the strength of brazed joints.

INFLUENCE OF INITIAL ANGULAR DEFORMATION ON STRESS CONCENTRATION FACTOR VALUE NEAR ROOT REINFORCEMENT OF BUTT WELDED JOINT

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This study investigates the influence of initial angular deformation on the stress-strain state of butt-welded joints. The analytical method for the local stress calculation is obtained. It allows us to define the value of the stress concentration factor (SCF) and the location of its maximum both on the face side and root side of butt joints with asymmetrical weld. The results of analytical calculations agree with those of numerical calculations using the finite element method. The comparison was made using the example of a thin-sheet TIG welded butt joint made of the aluminum alloy AMg6M. Since the SCF value is affected by only the joint shape, the method applies to other fusion welding processes. Obtained results contribute to the design procedures of butt joints made of different alloys using fusion welding processes.

HIGH FREQUENCY ELECTRIC WELDING OF INTESTINES

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The authors present the results of the research of the Paton Welding Institute in the field of high-frequency welding of pig intestines. In order to achieve the high-strength connections if intestine walls, the next steps were made:

- the stand for experimental studies on electric welding of the small intestine was developed and manufactured;
- the technology of applying a controlled pressure on the connecting tissues was created;
- the laboratory tools of various geometrical parameters for circular anastomosis were designed and manufactured;
- the methods of fixation of the pig's small intestine using the standard bipolar clamp (handpiece) and circular anastomosis tools were tested and improved;
- the welding algorithms with optimal parameters were developed for supplying high-frequency electric energy to the zone of influence on living tissue.

In 2023–2024, a few series of experiments (hundreds) were conducted to obtain the reliable energy-saving technologies for pig intestine welding.

Using the EKVZ-300-2 high-frequency coagulator and corresponded tools (handpieces), the welding algorithms were optimized; the high-strength connections were achieved. The strength of the connected tissues was measured in laboratory conditions — with a manometer or simply with the help of a water column by filling the welded tissue until its destruction.

The strength of intestine welded by the linear bipolar clamp was 1600–2800 mm water column. It corresponds to 119–207 mm Hg. As for the intestine welded by the circular anastomosis tool — the strength tests shown even higher figures — 2200–2800 mm of water column (163–207 mm Hg). Sometimes the maximum pressure that could be applied to the intestine was not enough to destroy it. If we compare our results with connections by traditional staplers (about 25 mm Hg), the welded intestine is 6–8 times more strong.

Here should be underlined that the circular tool needs much more energy comparing with a clamp, because the square of electrode is about 4 times more. But implementation of the power-saving algorithms allowed welding the tissue with bigger connection size.

The results of researches will be used for development of new tools for anastomosis welding. The PWI developers are looking for the customers to create new models of electrosurgical devices and tools by the contracts.