MAIN TOPICS, ABSTRACTS & KEY WORDS

Spreading characteristics of arc-assisted laser welding filler metals for welding-brazing butt joint between aluminum alloy and galvanized steel FAN Ding[1,2], WANG Bin[1], LI Chunling[1,2], HUANG Jiankang[1,2], YU Shurong[1,2] (1. State Key Laboratory of Advanced Processing and Recycling of Non-ferrous Metals, Lanzhou University of Technology, Lanzhou 730050, China; 2. School of Materials Science and Engineering, Lanzhou University of Technology, Lanzhou 730050, China). pp 1 – 5

Abstract: Butt welding-brazing joint between 5A06 aluminum alloy and ST04Z steel sheets was obtained by low power arc-assisted laser welding with preplaced filler powder. The influence of pre-welding gap, filling brazing flux, laser heat input, assistant arc current, heat source center distance and adding welding wire on spreading characteristics of the filler metal was studied by using SEM, Photoshop. The results show that the pre-welding gap less than 0.5 mm and the filling brazing flux on the welds' back were favorable. When the workpiece was not burn through, the weld spreading width was increased with the increase of the laser heat input and assistant arc current. With the increase of the distance to the heat source center, the weld spreading width first increaseed then decreased. Adding wire welding in the molten pool offers better spreadability, continuous and sound weld appearance can be obtained than the condition without wire addition.

Key words: spreading width; aluminum steel; arc-assisted laser; welding-brazing

Study on stress and strain of adhesive fillet of MOEMS package under temperature cycle LIANG Ying[1], HUANG Chunyue[2], ZHANG Xin[1], HUANG Wei[2], LI Tianming[3] (1. Department of Electronic Engineering, Chengdu Aeronautic Vocational and Technical College, Chengdu 610021, China; 2. School of Electro-Mechanical Engineering, Guilin University of Electronic Technology, Guilin 541004, China; 3. Department of Automobile and Power Engineering, Guilin University of Aerospace Technology, Guilin 541004, China). pp 6 – 10

Abstract: The stress and strain distribution on adhesive fillet of micro optical electro mechanical systems (MOEMS) package were analyzed under temperature cycle by using finite element analysis (FEA). The adhesive fillet thickness, fillet height and width were selected as three key configuration parameters, and an orthogonal design consisting of the 25 different combinations were conducted. The maximum stress and strain within the adhesive fillet were obtained. The variance analyses of stress and strain were performed. The results show that with 95% confidence, the adhesive fillet thickness and adhesive width have significant effect on the stress, the adhesive fillet thickness has significant effect on the strain. The adhesive fillet thickness, the adhesive width and the adhesive fillet height affect the stress and strain in a descending order. When the other parameters is unchanged, the maximum stress and strain descend with the increasing of the adhesive fillet thickness and the adhesive width under temperature load.

Key words: MOEMS; adhesive; temperature cycle; finite element analysis; variance analysis

A hybrid magnetism-inductance seam tracking method for narrow gap submerged arc welding HONG Bo, DAI Wei, LI Xiangwen, ZHU Yafei (Department of Mechanical Engineering, Xiangtan University, Xiangtan 411105, China). pp 11 – 14

Abstract: Aimed at these problems existing in seam tracking in narrow gap submerged arc welding, such as transverse seam tracking and tracking for both high position and low position, a novel electromegnetic sensor based on the principle of inductance was designed, which can scan the welding grove by the primary coil magnetic field and the collected current signal can be processed to derive the welding torch deviation and adjust the slider level movement for coping with the sidewall fusion. Through the variation of the secondary coil induction electromotive force, the location of welding torch can be obtained. The real-time identification of the relative height deviation of the welding torch can be used to track the bidirectional weld movement quickly and smoothly by using PID algorithm processing. The developed sensor has a simple structure with high sensitivity and strong anti-interference ability, therefore it provides a new solution to the thick plate of narrow gap submerged arc welding tracking.

Key words: thick steel of narrow gap; inductance; high and low tracking; PID controller

Corrosion rate of 2A12 aluminum alloy friction stir weld under salt solution WANG Lei[1,2], LI Pingyun[1], HUI Li[1,2], JI Shude[2,3], ZHANG Zhanchang[1] (1. Department of Mechanical and Electrical Engineering, Shenyang Aerospace University, Shenyang 110136, China; 2. Key Laboratory of Fundamental Science for National Defense of Aeronautical Digital Manufacturing Process, Shenyang 110136, China; 3. Department of Aerospace Engineering, Shenyang Aerospace University, Shenyang 110136, China). pp 15 – 19

Abstract: Static weight loss method was utilized to measure the average corrosion rate of friction stir weld 2A12 aluminum alloy joint under 3.5% NaCl solution. The variation of corrosion rates under different corrosion time was studied based on the analysis of corrosion mechanism, corrosion product composition and morphology of corrosion damages. Results showed that the average corrosion rate decreased dramatically at the beginning and then rose slowly which was closely related to the change of corrosion mechanism from pitting to intergranular corrosion, which finally became to exfoliation corrosion. The weld was corroded more seriously under longer corrosion time according to the quality removal ratio. Different zones of the weld have different corrosion sensibility, namely, the weld nugget has most serious corrosion, followed by the front side and the retreating side was corroded slightly.

Key words: friction stir welding; corrosion rate; corrosion mechanism; secondary phase

Analysis on critical temperature field during ultrasonic welding of thermoplastics ZHANG Zongbo[1], HE Qingqiang[1], LUO Yi[2], WANG Xiaodong[2], WANG Liding[2] (1. College of Mechanical and Electronic Engineering, China University of Petroleum, Qingdao 266580, China; 2. Key Laboratory for Micro/Nano Technology and System of Liaoning Province, Dalian 116024, China). pp 20 – 22

Abstract: The heat induced by friction and viscoelastic effect in the ultrasonic welding thermoplastics was calculated via multi-physics coupling model. Based on the calculation, influences of ultrasonic amplitude on the temperature field of weld zone were studied. Moreover, the existance of critical amplitude, below which the thermoplastic would not flow, was discovered during ultrasonic welding. Temperature-measurement test was carried out to verify the simulation. The simulation results agreed well with experiment results. And the temperature field under critical amplitude was discussed. The study of critical temperature field in this paper will contribute to solving the problem of temperature controlling during ultrasonic welding and to laying the foundation for non-melting joining of thermoplastics using ultrasonic vibration.

Key words: ultrasonic welding for thermoplastics; critical amplitude; critical temperature field

Finite element analysis of temperature field in single wire FAB submerged arc welding of thick steel plate PU Juan[1,2], YU Shengfu[1], XU Guoxiang[2] (1. School of Materials Science and Engineering, Huazhong University of Science and Technology, Wuhan 430074, China; 2. School of Materials Science and Engineering, Jiangsu University of Science and Technology, Zhenjiang 212003, China). pp 23 – 28

Abstract: Based on macro heat transfer mechanism, a three dimensional numerical analysis model for temperature field in single wire FAB (flux aided backing) submerged arc welding of thick plate was established by considering the influence of groove on welding heat input and the geometry of the weld cross section. The temperature field and the thermal cycle in FAB welding of D32 steel for different thicknesses were calculated using ANSYS software and the thermal field was analyzed. The results show that the calculated weld cross section shape and size as well as the thermal cycle were in fair agreement with experimental data, indicating the accuracy and adaptively of the model. In the condition of good weld formation, with the raise of plate thickness, the width of HAZ at the top and bottom surface of the work piece decreased to some extent, but the cooling time $t_{8/5}$ of thermal cycle had no obvious changing tendancy.

Key words: thick steel plate; FAB submerged arc welding; temperature distribution; numerical analysis

Pulse variable polarity plasma arc welding technology of aluminum alloy CHUN Lan[1,2], HAN Yongquan[1], CHEN Furong[1], HONG Haitao[1] (1. Material Forming Key Laboratory of Autonomous Region, Inner Mongolia University of Technology, Hohhot 010051, China; 2. Engineering Training Center, Inner Mongolia University of Technology, Hohhot 010051, China). pp 29 – 32

Abstract: A variable polarity plasma arc (VPPA) welding system that has single power supply and double pulse hybrid modulation is developed. High-low frequency pulse is modulated on the basis of typical VPPA welding power, in which high frequency is from 1 kHz to 5 kHz, low frequency is from 1 Hz to 2 Hz and double pulse consisting of both high and low frequency can be generated. With the utilization of tensile test, SEM observation, the welding quality and mechanical properties of the welded 3003 aluminum joints are analyzed. The test results show that because of the effect of stirring and impacting on molten pool exerted by the periodicity variation of pulse current, the tensile strength of the weld joint is improved, the weld grains are refined and the fracture dimples are uniform and dense. Thus, the quality of the aluminum alloy welds is improved.

Key words: high-low frequency pulse modulation; variable polarity plasma arc; welding technology

Transformation of interfacial microstructure in aged Sn-Zn-Nd solder joint XUE Peng[1], WANG Kehong[1], ZHOU Qi[1], HE Peng[2], LONG Weimin[3], ZHONG Sujuan[3] (1. School of Materials Science and Engineering, Nanjing University of Science and Technology, Nanjing 210094, China; 2. State Key Laboratory of Welding and Joining, Harbin Institute of Technology, Harbin 150001, China; 3. State Key Laboratory of Advanced Brazing Filler Metals & Technology, Zhengzhou Research Institute of Mechanical Engineering, Zhengzhou 450001, China). pp 33 – 36

Abstract: The interfacial microstructure in Sn-Zn-Nd solder joint aged at 360 hours, 720 hours, and 3 000 hours was investigated respectively. The results indicated that the transformation of interfacial intermetallic compound layer was dominated by the atom diffusion. After long-term aging, the composition of intermetallic compound layer transformed from Cu5Zn8 into a mixed Cu-Zn-Sn compounds. During the aging process, the diffusion-induced stresses also accumulated at the interface between solder matrix and Cu pad. When it reached a certain value, voids and fractures was formed in the intermetallic compound layer, which deteriorated the soldered joint properties.

Key words: Sn-Zn; solder joint; interface; intermetallic compound

Weld detection of laser welding using magneto-optical color imaging MO Ling[1], GAO Xiangdong[1], XIAO Zhenlin[2], CHEN Xiaohui[2] (1. School of Electromechanical Engineering, Guangdong University of Technology, Guangzhou 510006, China; 2. Guangzhou Panyu Gofront Dyeing & Finishing Machinery Manufacturer Ltd., Guangzhou 511400, China). pp 37 – 40

Abstract: This paper proposes a novel method to realize accurate seam tracking of butt micro-gap (less than 0.1mm) joint during laser welding based on the magneto-optical color images. Images of weld seam zone are captured by a magneto-optical sensor, and grayscale distribution of the weld seam magneto-optical images in the RGB(Red, Green, Blue) and HSV(Hue, Saturation, Value) color space are analyzed. The grayscale map of component of the RGB figure is extracted, and weld seam edge is determined based on the threshold derived from the grayscale distribution curve of each component. Also, the outline of weld seam transitional zone is obtained by integrating weld seam edges of the three components. The histogram of each HSV component is analyzed to determine the threshold and then the synthetic seam transition zone segmentation is obtained. Experimental results show that the proposed method can effectively detect micro-

gap weld seam which is generally hard to distinguish by human eyes.

Key words: RGB image; HSV space; seam recognition; magneto-optical image

Numerical analysis of fixed point A-TIG welding with free surface SHENG Wenwen, FAN Ding, HUANG Jiankang, HUANG Lin, HUANG Yong (State Key Laboratory of Advanced Processing and Recycling of Non-ferrous Metals, Lanzhou University of Technology, Lanzhou 730050). pp 41 – 45

Abstract: According to the basic principles of fluid mechanics, tracking the free surface by using VOF method, a three dimensional mathematical model for fixed-point A-TIG welding was established. Considering the buoyancy, electromagnetic force, arc pressure and surface tension of liquid metal in the molten pool, as well as the convection, radiation and heat transfer, the FLOW-3D software was used to simulate the fixed-point A-TIG welding molten pools′ free surfaces, temperature fields and flow fields, in particularly, the free surfaces of the molten pools with or without active flux was analyzed. The results show that in case of the process without active flux addition, the free surfaces′ centers are concave surrounded by convex surface, while in case of the process with active flux, surface tension temperature coefficient changed from negative to positive, thus free surfaces′ centers are convex, and the periphery is concave. When the welding current is 150 A or less, the simulated result of the molten pools′ temperature fields, flow fields and shapes with the consideration of free surface are consistent with the experimental results, as well as the simulated process without considering free surface.

Key words: molten pool; free surface; flow field; surface tension temperature coefficient

Finite element analysis of electromagnetic force in GMAW melt pool induced by external magnetic field BAI Xingwang[1,2], ZHANG Haiou[1], WANG Guilan[3] (1. School of Mechanical Science and Engineering, Huazhong University of Science and Technology, Wuhan 430074, China; 2. School of Mechanical Engineering, University of South China, Hengyang 421001, China; 3. School of Materials Science and Engineering, Huazhong University of Science and Technology, Wuhan 430074, China). pp 46 – 50

Abstract: A simulation method based on simplified arc model is developed for the analysis of GMAW deposition with various external magnetic fields. The electromagnetic force distributions in the workpiece produced by longitudinal and transversal magnetic fields are systematically investigated in comparison with the case without external field. The results reveal that the inherent electromagnetic force of GMAW welding drive the converging and sinking flow in the central of melt pool. The external longitudinal field results in circumferential electromagnetic force which stirs the melt pool, which in turn refine the microstructure. The external transversal field of specific direction could convert the melt convection into "single-vortex" state which help the melt pool to absorb molten droplet and therefore reduce the spatter. The agreement between experimental data and the simulation results verifies the reliability and universality of the numerical model.

Key words: electromagnetic force in melt pool; simplified arc model; external magnetic field

Effect of welding on bearing capacity of launch vehicle tank based on Neuber formula LIN Yitong[1,2], WANG Dongpo[1,2], WANG Ying[1,2] (1. School of Materials Science and Engineering, Tianjin University, Tianjin 300072, China; 2. Tianjin Key Laboratory of Advanced Joining Technology, Tianjin 300072, China). pp 51 – 54

Abstract: The maximum internal pressure in large launch vehicle tank made of 2219 aluminum alloy in the process of liquid bulge test was estimated according to Neuber formula. The small-area mechanical property of the joint was tested through micro-mechanical tests. The theoretical elastical stress concentration factor of welded toes at different structural models was obtained by linear-elastic finite element method. Finally, the small-area mechanical properties were adopted in the finite element model and the elastic-plastic structural analysis was carried out to verify the accuracy of Neuber formula in the calculating the bearing capacity of the tank. By comparison, the predicted local mechanical properties and stress concentration caused by geometrical defects seriously affect the bearing capacity of structure. Under extremely hazardous condition, the stress concentration factor could reach 5.156, and bearing capacity was only 1.21 MPa, as 37.81% of that one without weld. The stress variation of neuber formula was 8.5% and the strain variation was 2.3%, so the precision of Neuber formula is relatively high to estimate the bearing capacity of structure.

Key words: Neuber formula; tank of 2219 aluminum alloy; welding manufacturing; bearing capacity; finite element method

Large curvature curved seam tracking based on dynamic tangent of weld LIU Jian, HONG Bo, HONG Yuxiang, LI Yi (Institute of Mechanical Engineering, Xiangtan University, Xiangtan 411105, China). pp 55 – 58

Abstract: Aiming at curved seam tracking with large curvature that wheeled welding mobile robot encountered in shipbuilding and large spherical tank welding, a method of dynamic tangent to weld seam is proposed on the basis of real-time wavelet denoising method and weld seam tangent, with combination of sliding-mode variable control. The mathematic model based on the method is established, the simulation performed at MATLAB and welding experiment were carried out to verify this model. The experiment and simulation results indicate that this method can perform real-time speed correction for welding vehicle with fixed step, keeping the welding torch moving with constant tangential velocity along seam trajectory, and thus it guarantees the welding quality and achieves real-time automatic curved seam tracking. It provides a new theoretical thought for the application of wheeled welding mobile robot in automatic seam tracking with complicated trajectory.

Key words: wheeled welding mobile robot; seam tracking; real-time wavelet de-noising; method of tangent to weld seam

R-δ-type weldability window of double vertical explosive welding WANG Yu[1], SHI Changgen[2], YOU Jun[2], ZHAO Linsheng[2], HOU Hongbao[2] (1. 63981 Troops PLA, Wuhan 430311, China; 2. PLA University of Science and Technology, Nanjing 210007, China). pp 59 – 62, 75

Abstract: Based on the detonation characteristics in a

new double vertical explosive welding process, the R-δ-Type weldability window of double vertical explosive welding with static parameters is established, by studying the boundary conditions including, lower limit, upper limit, critical initiation thickness, critical collision angle, the critical plate thickness, etc. The R-δ-type weldability window reflects the relevance between the material properties and explosive characteristics, which are the two most important welding parameters of explosive welding. The R-δ-type weldability window for copper, stainless steel, aluminum and other materials can be directly utilized in engineering practice. A welding experiment between 304L and Q235b has been done with the ultra-low charge of 15 millimeter thickness based on the R-δ-type weldability window for double vertical explosive welding. The bonding quality of 304L/Q235b composites after welding is good with small wavy combination on the interfaces, which indicates that the proposed window can be used to determine the process parameters of double vertical explosive welding.

Key words: explosive welding; weldability window; double vertical method; R-δ-type

Numerical simulation of welding temperature field of electro slag welding with forced cooling SUN Jiamin, HE Jing, DENG Dean (School of Material Science and Engineering, Chongqing University, Chongqing 400044, China). pp 63 – 66

Abstract: In order to clarify the influence of forced cooling on the width of heat affected zone(HAZ) and $\Delta t_{8/5}$ of electro slag welding(ESW), a computational approach based on MSC. Marc software was developed to predict the welding temperature field. In the proposed approach, welding temperature field induced by ESW under varying cooling conditions (air, copper and water cooling) were computed by using a half ellipsoid volumetric heat source model with uniform density and the temperature-dependent thermo-physical properties of SM490A was obtained from experiment. In addition, the thermal cycles at several typical locations were measured in the ESW joint by K-type thermocouple. The results show that the temperature histories predicted by numerical simulation are in good agreement with experimental results. The numerical results indicate that forced cooling has a limited influence on the size of fusion zone, however, copper cooling and water cooling can significantly reduce the width of HAZ and largely shorten $\Delta t_{8/5}$ time.

Key words: electro slag welding; forced cooling condition; heat source with uniform density; welding temperature field

Study on feedback of power source in short-electric arc machining CAO Jiong[1], ZHOU Jianping[1,2], XU Yan[1], YIN Yiliang[1], XU Yihao[1] (1. School of Mechanical Engineering, Xinjiang University, Urumqi 830047, China; 2. School of Mechanical Engineering, Xi′an Jiaotong University, Xi′an 710049, China). pp 67 – 70

Abstract: In order to make the arc discharge channel be more easily and effectively established in short electric arc machining (SEAM), this paper established a simulation model of the power source based on Matlab and verified the feasibility and stability of the feedback loop in SEAM process. Through short arc electric cutting machining experiment, the electrical characteristics of the power source in SEAM, it meets the requirements of SEAM. The resutls provide important technical support for the understanding the short electric arc machining mechanism.

Key words: short electric arc machining (SEAM); discharge channel; gain characteristic; feedback loop

Study on welding residual stress and distortion of Q345/SUS304 dissimilar steel butt weld CAI Jianpeng, HE Jing, ZHANG Yanjie, DENG Dean (1. College of Materials Science and Engineering, Chongqing University, Chongqing 400044, China; 2. Chongqing ChangZheng Heavy industry Co., Ltd., Chongqing 400083, China). pp 71 – 75

Abstract: Based on ABAQUS software, a computational approach was developed to simulate the welding temperature field, the residual stress distribution and the deformation of Q345/SUS304 dissimilar steel multi-pass welding joint with a thickness of 10 mm. Meanwhile, experiments were carried out to measure welding residual stresses, transverse shrinkage and angular distortion of the butt weld. Through comparing the simulated results with the measured data, it was found that both residual stresses and deformation predicted by the numerical model were in good agreement with the experimental measurements. The simulation results show that the longitudinal residual stress distribution is discontinuous near the fusion line between Q345 and weld metal, and the longitudinal stresses next to the fusion line in the Q345 steel side are significantly lower than those in the both sides of this region. Also, another interesting phenomenon is that the region with high tensile stress in SUS304 side is wider than that in Q345 side. In addition, both the simulation results and the experiment measurement indicated that a relatively large angular distortion was produced in the joint after welding.

Key words: dissimilar steel welding; numerical simulation; residual stress; welding deformation

Effect of processing parameters on microstructure and mechanical properties of friction stir welded 7A04 aluminum alloy joints ZHENG Xiaomao, ZHANG Datong, ZHANG Wen, QIU Cheng (School of Mechanical and Automotive Engineering, National Engineering Research Center of Near-Net-Shape Forming for Metallic Materials, South China University of Technology, Guangzhou 510640, China). pp 76 – 80

Abstract: 7A04 aluminum plates with a thickness of 3mm were welded by friction stir welding (FSW). The microstructure, precipitates mechanical properties and fractured surfaces of the joints were investigated. The results show that the microstructure of the nugget zone consists of fine equiaxed grains due to dynamic recrystallization with precipitates dissolved, and the average grain size of the nugget zone decreases with welding speed increasing. According to the microhardness test, the hardness of the nugget zone is lower than that of the parent material and the lowest hardness locates at HAZ. The ultimate tensile strength (UTS) reaches its peak value (454.2 MPa), at a welding speed of 120 mm/min, which is 95% of the parental material. The elongation of the joint is 3.97% under this parameter. The SEM observed fracture morphologies indicate that the joint fails through a mixture ductile and brittle mode.

Key words: 7A04; friction stir welding; microstructure; mechanical properties

Small-signal modeling for peak current mode PSFB-ZVS PWM arc-welding inverter and control loop design HE

Yaning (Chengdu Xionggu Jiashi Electrical Co., Ltd., Chengdu 611731, China). pp 81 – 84

Abstract: For the development of a digitalized 20 kW/50 kHz pulsed MIG/MAG arc-welding inverter, the Peak current mode PSFB-ZVS PWM converter topology is used to improve the accuracy and dynamic response of the control system. Thesmall-Signal model for power stage of PSFB-ZVS PWM in CCM is derived using the averaged switch modeling approach. A complete small-signal model of the peak current mode PSFB-ZVS PWM arc-welding inverter is derived based on the derivation of the small-signal model for peak current mode control stage. The design principle of slope compensation is derived. A PI frequency compensator is designed. The analytical result of small-signal model is accord with the frequency response through the frequency domain simulation using Simplis software.

Key words: inverter; arc-welding power supply; peak current mode; averaged switch modeling; small-signal model

Analysis on main factors of resistance spot welding spatter of galvanized sheet based on structure-bearing acoustic emission signals LUO Yi[1,2], ZHU Yang[1,2], WAN Rui[1,2], XIE Xiaojian[1,2] (1. School of Materials and Engineering, Chongqing University of Technology, Chongqing 400054, China; 2. Chongqing Municipal Engineering Research Center of Institutions of Higher Education for Special Welding Materials and Technology, Chongqing 400054, China). pp 85 – 89

Abstract: According to the acoustic emission (AE) signals detected in resistance spot welding (RSW) on galvanized steel sheet, the main inducing factors of welding spatter were analyzed by orthogonal experimental design (OED) and the analysis of variance (ANOVA). The results showed that the equivalent released energy by welding spatter can be assessed by two characteristic parameters: positive peak value and AE count. The most important factor inducing welding spatter is welding current, the second factor is pressure. The importance of welding duration and interaction of welding current and electrode pressure is close. The welding current and welding duration have a positive effect on the equivalent weight of spatter. While the electrode pressure has a negative effect on the equivalent weight of welding spatter.

Key words: resistance spot welding; galvanized steel sheet; spatter; acoustic emission; orthogonal experimental design

Analysis of turbulent flowing zone in friction stir welded aluminum alloy weld nugget LUO Chuanhong[1], GUO Lijie[2], DONG Fengbo[2], ZHANG Jianqiang[1], PENG Weiping[1] (1. School of Power and Mechanical Engineering, Wuhan University, Wuhan 430072, China; 2. Shanghai Aerospace Equipments Manufacturer, Shanghai 200245, China). pp 90 – 94

Abstract: A 2219-T6 aluminum alloy plate was welded by friction stir welding, and the morphology, microstructure and mechanical properties of the joint were investigated correspondingly. Through analyzing the flowing pattern of the plastically deformed metal in the nugget zone, the strength weakening of the joint were analyzed and summarized. The results show that the welded nugget is divided into three different regions according to the flowing pattern of plastic metal, and a turbulent flowing region is produced by unbalanced suction and extrusion of plastic metal at the front side of joint. This region with weak mechanical properties is a channel for the back flow of plastic metal. The weakening strength is due to the plastic deformation induced damage of the metal, which resulted in the formation of defects and the mutational interface. Moreover, grains in the turbulent flowing region presented large thermal instability. After the recrystallization heat treatment, the joint can restore the ductility, which will improve the mechanical properties of the joint.

Key words: aluminum alloy 2219; friction stir welding; mechanical properties; microstructures

Vacuum diffusion bonding of textured WC-Co cemented carbide and aluminum ZHANG Lixia, ZHANG Ruoheng, YANG Jinghong, LEI Min (State Key Laboratory of Advanced Welding and Joining, Harbin Institute of Technology, Harbin 150001, China). pp 95 – 98

Abstract: The surface of WC-Co hard metal was mechanically textured and then precoated using BNi2 brazing filler metal, then the WC-Co/Al joint was prepared by vacuum diffusion bonding. The results indicated that the microstructure of the interface is aluminum/Al_3Ni + Al_3Ni_2 + Al_5Co_2/Co-Ni(s. s)/W-Co-Ni/WC-Co. With the increasing of the precoating temperature, the volume of layer of W-Co-Ni compound increased and the morphology of the interface of WC-Co/BNi2 transformed from flat to irregular. With the increasing of diffusion bonding temperature, the thickness of Al_3Ni + Al_3Ni_2 + Al_5Co_2 layer increased. It was found that when the bonding parameters increased, the shear strength of the joints increased in the first stage and then decreased. The maximum shear strength of WC-Co/BNi2/Al joints was 51MPa, with a precoating temperature of 1 050 ℃, diffusion bonding temperature of 575 ℃ with holding time of 90 minutes, which largely exceeded the shear strength of the joints without surface texturing pretreatment.

Key words: texturing; WC-Co cemented carbide; aluminum; precoating; diffusion bonding

Parametric study on friction stir welding of Q235 steel with 6082 aluminum alloy WANG Xijing, DENG Xiangbin, WANG Lei (State Key Laboratory of Advanced Processing and Recycling of Non-ferrous Metals, Lanzhou Universty of Technology, Lanzhou 730050, China). pp 99 – 102

Abstract: The paper used orthogonal experiment to optimize the friction stir spot welding welding process of of Q235 steel and 6082 aluminum alloy plate. Results showd that when the Q235 steel plate was placed on the backward sidethe-metal at the steel side and near the stir pin was softened, and then short nail was formed under the shear stress induced by transverse-moving shoulder, ultimately the softened metal filled in the formed cavity at the rear of the stir by stir spinning. A pressed depth of 0.2 mm is favorable to form high-quality welds. When the rotation speed is 260 RPM, welding speed is 21 mm/min and pin offset is 0.2 mm towards aluminum alloy plat side, the tensile strength of the weld is 141.204 MPa, fracture occurs at the interface zone between the weld nugget area and the heat affected zone. The hardness of the heat affected zone at steel side was higher than parent metal while that near the aluminum alloy plat side was lower than the parent metal.

Key words: Q235; 6082 aluminum alloy; friction stir spot welding; optimize welding process

Effect of magnetic field on shape of magnesium alloy weld pool LIU Zhengjun, WANG Xiaohui, SU Yunhai (Materials Science and Engineering, Shenyang University of Technology, Shenyang 110870, China). pp 103 – 106

Abstract: Taking magnesium alloy weld pool as the research object, a three-dimensional mathematical model of the weld pool under moving heat sources was established. The electromagnetic field analysis is coupled with the heat flow analysis using the finite element software ANSYS. The temperature distribution and the velocity vector distribution of the fluid flow in magnesium alloy weld pool were simulated under the effect of the external magnetic field and without external magnetic field. The simulation results show that the electromagnetic force induced by external magnetic field driving the molten liquid metal occurs a rotary motion, which changed the original movement of liquid metal and heat transfer. The fluid flow velocity and flow range was therefore increased, with increased weld width and reduced depth. The experimental results verify the simulation results.

Key words: external magnetic field; temperature distribution; fluid flow; numerical simulation

Novel semi-dry type underwater overhead electrode welding technology CHENG Fangjie[1,2], ZHANG Zhe[1], DENG Caiyan[1,2], GAO Wenbin[1], WANG Dongpo[1,2] (1. School of Materials Science and Engineering, Tianjin University, Tianjin 300072, China; 2. Tianjin Key Laboratory of Advanced Joining Technology, Tianjin 300072, China). pp 107 – 110

Abstract: In order to overcome the difficulty of wet-type underwater electrode welding, a novel p semi-dry type underwater overhead welding was proposed. The principle of the process and the operation procedure was clarified it's the welding ability, weld microstructure, hardness and diffusion hydrogen content were studied. The results indicate that this semi-dry overhead welding procedure can be successfully applied in underwater overhead welding position and the appearance of weld is good. The optimum welding current range is 100-140 A for electrode of ϕ3.2 mm diameter, the corresponding welding voltage range is 28-32 V. The weld microstructure is mainly composed of ferrite side-plate, needle-like ferrite and bainite. Compared with the traditional underwater wet-type welding, the content of ferrite increased, and the content of bainite decreases accordingly. The highest hardness of welded joints and diffusion hydrogen content in deposited metal are remarkably lower than those of the wet-type underwater electrode welding.

Key words: underwater overhead welding; weld formation; microstructure; diffusion hydrogen; hardness

Microstructure and cavitation erosion resistance of NiCrWFeSiBCCo coatings XIA Ming, LI Gaiye, WANG Zehua, HU Yaqun (Colleye of Mechanics and Materials, Hohai University, Nanjing 210098, China). pp 111 – 114

Abstract: A NiCrWFeSiBCCo coating was prepared on 1Cr18Ni9Ti steel substrate by means of high-velocity oxygen-fuel (HVOF) thermal spraying process. The Microstructure, surface morphology before and after cavitation erosion test was carried out using the optics metallographic microscope (OM), Stereoscopic microscope (SM), scanning electron microscope (SEM). The surface roughness is measured by profilometer tester. The hardness is measured by hardness tester. Phase composition of the coatings was analyzed using the X-ray diffraction (XRD). The cavitation properties of the coating is tested using the ultrasonic vibration cavitation device which is compared with 1Cr18Ni9Ti stainless steel. The results show that a uniform microstructure, dense NiCrWFeSiBCCo coating (low porosity of 0.63%) is prepared by HVOF and the NiCrWFeSiBCCo coating's microhardness is 1 004 HV. The cavitation erosion resistance of the NiCrWFeSiBC cocoating is better than that of 1Cr18Ni9Ti stainless steel.

Key words: high velocity oxy-fuel spraying; coating; cavitation erosion resistance

Three-dimensional transient numerical simulation of melting pool in CO_2 short-circuiting arc welding XIA Shengquan[1], SUN Xiaoming[2] (1. China Academy of Engineering Physics, Mianyang 621900, China; 2. Department of Mechanical Engineering, Tsinghua University, Beijing 100084, China). pp 115 – 119

Abstract: Due to the randomness in the CO_2 short-circuiting arc welding, the adaptive model of droplet considering the initial size, the initial temperature and the time of short-circuits between drop and melting pool is set up in the numerical model. Then the three-dimensional transient model of CO_2 short-circuiting transfer welding pool was set up. In model, the asymmetric Gauss heat source was adopted taken into account the asymmetric of welding arc's heat flux density along welding direction, the VOF model was adopted to track the gas-liquid interface, the enthalpy-porosity technique was used to compute the momentum sink in the mush zone; the additional source term method was used to add the main force of pool, such as arc pressure, the electromagnetic force, the buoyancy and so on. The evolution of the temperature field and flow field was computed with the model in the CO_2 short-circuiting arc welding of 6mm thick low carbon steel. The probability density distribution of short-circuiting time interval and the final weld formation under the simulation condition was well agreed with experimental result.

Key words: short-circuiting transfer; pool; adaptive model of droplet; randomness

Review on high temperature resistant packaging technology for new genetation power semiconductor devices FENG Hongliang, HUANG Jihua, CHEN Shuhai, ZHAO Xingke (School of Material Science and Engineering, University of Science and Technology Beijing, Beijing 100083). pp 120 – 128

Abstract: The new generation semiconductor materials have good conversion characteristics and heat tolerance, enabling the power electronic devices to operate at 500 ℃ or even higher, however, their usage over such wide temperature ranges is limited by the temperature stability of packag. This paper presents the structural requirements of high temperature resistant packagingand analyzes the current research status of high temperature resistant joining technologies (including high temperature lead-free solder joining, low temperature silver sintering-bonding, solid-liquid inter-diffusion bonding and transient liquid phase sintering-bonding) as well as problems. The future challenge and prospect related to high temperature resistant packaging is also proposed in this article.

Key words: power electronic devices; high temperature resistant packaging; joining; transient liquid phase sintering