**MAIN TOPICS, ABSTRACTS & KEY WORDS**

**Finite element analysis on master cylinder welding stress field of 80,000 tons of die forging press**

CHEN Zhongyi, QIAO Weichao, MA Yonglin, XING Shuqing (School of Materials and Metallurgy, Inner Mongolia University of Science and Technology, Baotou 014010, China) . pp 1 – 6

**Abstract:** In order to investigate welding stress distribution and deformation of master cylinder on 80,000 tons of die forging press, the master cylinder welding simulation model was built using finite element method, and the results of the master cylinder temperature field, stress and deformation were obtained. The results show that the maximum temperature of master cylinder is about 2100°C, appearing in the weld area, and the maximum temperature gradient occurs in the joint area during the welding process. After the welding, the maximum displacement of the master cylinder is about 8 mm, located on top of the master cylinder, and the displacement amount of the weld zone is smaller compared to top of the master cylinder. In order to prevent large deformation and ensure assembly accuracy after welding, the displacement at top and bottom of the master cylinder must be constrained before welding. The maximum stress of master cylinder is about 470 MPa, appearing in the weld area, the stress in heat-affected zone is lower, which followed by the base metal zone. Before the heat treatment, it should be checked whether there are cracks on the surface of welding or other welding defects. These results can provide calculated data reference for actual production of the master cylinder.

**Key words:** large-scale structural component; high strength low alloy steel; finite element method; residual stress; experimental verification

**Research of mechanical properties of adhesive bonding of single lap joints with reinforcements**

WANG Youqi, HE Xiaoceng, ZENG Kai, XING Baoying (Innovative Manufacturing Research Centre, Faculty of Mechanical and Electrical Engineering, Kunming University of Science and Technology, Kunming 650000, China) . pp 7 – 12

**Abstract:** In order to enhance the mechanical properties of adhesive bonding of single lap joints (SLJs), the adhesive bonding of SLJs with reinforcements was designed based on Goldan and Reissner’s one-dimensional beam theory model. The adhesive bonding of SLJs whose adherends were aluminum alloy 5052 (AA joints), Al5052 with reinforcement (AAT joints) were separately tested under tension-shear loading and fatigue load, and the effectiveness of experimental data was analyzed by Normal distribution and Weibull distribution. The results show that the mechanical properties of joints are influenced by the stiffness at the end of the overlap region. The static strength of AAT joints increased by 3.8%. The energy absorption capacity of AAT joints increased by 60.2%. The deformation of AAT joints reduced by 38.5%. The fatigue properties of AAT joints increased by 30.3%.

**Key words:** adhesive single lap; reinforcements; one-dimensional beam theory model; mechanical properties

**Effect of process parameter on powder flow statues in coaxial powder feeding**

YANG Yicheng, WANG Wei, WANG Xuyou, HUANG Ruisheng (Harbin Welding Institute, Harbin Academy of Machinery Science & Technology, Harbin 150028, China) . pp 13 – 17

**Abstract:** In this study, the macro morphology of the powder flow was obtained using a high speed camera, and image gray processing was implemented to study the effect of process parameters on powder flow feed behavior. The feasibility of research method was estimated. Results showed that the powder density can be obtained accurately from the gray level information. Distribution of the powder density in cross section at the focus position typically obey Gaussian distribution. The effect of powder feed rates on the position of powder focus can be neglect. With the increase of carrier gas flow rate, the position of powder focus and diameter of the focus plan decrease. The critical value of coaxial protect gas flow rate was 8 L/min, the trajectory of powders maybe changed for vortex phenomenon when greater than this value.

**Key words:** high speed camera; gray value; powder flow; gaussian distribution

**Study on temperature field of electron beam welding of TC4 titanium alloy pressure vessel**

ZHANG Yonghe, HE Jun, ZHAI Dapeng, ZHANG Binggang (1. Science and Technology on Vacuum Technology and Physics Laboratory, Lanzhou Institute of Physics, Lanzhou 730000, China; 2. State Key Laboratory of Advanced Welding and Joining, Harbin Institute of Technology, Harbin 150001, China) . pp 18 – 21, 48

**Abstract:** In order to meet the requirement of welding quality of space pressure vessel and the protection requirements of special equipment inside, it is necessary to determine the welding specification by using the specimen before welding. The temperature field of TC4 titanium alloy pressure vessel specimen under certain process conditions was studied by using the rotating Gaussian surface heat source model. The distribution characteristics of temperature field and the thermal cycle curve of welding process were obtained, and it was proved that by using the distribution of the temperature gradient in the heat affected zone of the specimen provides the basis for the protection of the internal device. By simulating the evolution of the “key hole” and the characteristic dimensions at different welding speed, the welding parameters are analyzed and determined, it can provide a reference for obtaining high-quality requirement of the welding seam.

**Key words:** pressure vessel; titanium alloy; temperature field

**Identification of high-power fiber laser welding penetration based on fuzzy clustering algorithm**

GAO Xiangdong, LIANG Jianbin, LIU Guiqian, ZHANG Yanxi (School of Electro-mechanical Engineering, Guangdong University of Technology, Guangzhou 510006, China) . pp 22 – 25

**Abstract:** Weld penetration is an important standard
which evaluates the laser welding quality. However, it is difficult to directly measure the weld penetration during laser welding. Controlling the weld penetration can only be carried out through an indirect estimation of weld penetration by other sensing signals. A novel approach of weld penetration status identification based on molten pool infrared image processing is proposed during butt joint high-power fiber laser welding of type 304 austenitic stainless steel plates with laser power of 6 kW. An infrared high speed camera was used to capture the dynamic infrared images of molten pool. Characteristic parameters of a molten pool image were extracted by image processing, and fuzzy clustering algorithm was used to explore the relation between the molten pool parameters and the weld penetration status. An identification model of weld penetration status was established by using the fuzzy C-mean (FCM) and Gustafson-Kessel (GK) algorithm, respectively. Welding experiments confirmed that the molten pool surface characteristic had a close inherent relationship with the weld penetration, and the weld penetration status could be estimated by the proposed GK fuzzy clustering identification model, which could provide an experimental basis for detection and control of weld penetration.

**Key words:** high-power fiber laser welding; weld penetration; fuzzy clustering; infrared image

**Differential analysis for temperature distribution diagnostics of arc current-carrying region with low disturbance electrostatic probe**  
Li Yuanbo¹, Li Xiao¹, SHI Quanfu², LIU Jing¹, LI Kai¹ (1. College of Materials Science and Engineering, Xi’an Shiyou University, Xi’an 710065, China; 2. Lanzhou University of Finance and Economics, Lanzhou 730101, China) . pp 26 – 30

**Abstract:** The differential analysis of low disturbance electrostatic probe was developed for local micro-measurement of TIG arc current-carrying region temperature. The temperature of TIG arc current-carrying region can be solved by ion saturation current of electrostatic probe. Furthermore the temperature distribution in different welding current and arc length can be also obtained. The results show that the variation trend of TIG arc current-carrying region temperature acquired by probe, which agrees with results of spectroscopic method; because of cool disturbance of probe, the temperature solved by ion saturation current is lower than temperature measured by spectroscopic method; the distribution width of TIG arc current-carrying region temperature reduces to the smallest near cathode along the arc axial direction; the temperature rises to maximum at the center of TIG arc current-carrying region cross section along arc radial direction, and there is a region with higher temperature near cathode; when the welding current decreased, the highest temperature of TIG arc current-carrying region would be lowered, meanwhile the current-carrying region temperature distribution width reduced, and then the high temperature region near cathode tends to shrink along arc axis; the longer arc length cause spatial range of charged particles enlarged, this gives rise to expand distribution width of TIG arc current-carrying region temperature, but the highest temperature of TIG arc current-region would not change.

**Key words:** arc; current-carrying region; temperature distribution; electrostatic probe

**Longitudinal structural stress constructing approach for non-load-carrying T welded joints bearing longitudinal load**  
DONG Yafei¹,²,³, WEI Guoqian¹,²,³, QI Jinxian¹,², YU Xi¹,², HE Yibin¹ (1. School of Machinery and Automation, Wuhan University of Science and Technology, Wuhan 430081, China; 2. Hubei Provincial Key Laboratory of Chemical Equipment Intensification and Intrinsic Safety, Wuhan Institute of Technology, Wuhan 430205, China; 3. Hubei Provincial Key Laboratory of Chemical Equipment Intensification and Intrinsic Safety (WIT), Wuhan 430205, China) . pp 31 – 34

**Abstract:** In order to analyze the fatigue life of non-load-carrying T welded joints bearing longitudinal load, longitudinal structural stress and its constructing approach were proposed. Nodal loads normal to the weld section were converted to the distributed loads along the element edges. Analysis formula of membrane stress and bending stress was established by force balance theory. Equivalent plate thickness was proposed based on the base metal thickness and the weld height. Then the longitudinal structural stress at weld toe was calculated. The approach was verified by fatigue test for non-load-carrying T welded joints bearing longitudinal load. Results show that this approach has obvious advantages to analyze longitudinal loading welded structures, which can be employed to calculate fatigue life by revised equilibrium-equivalent formula, and the master S-N curve according to the theory previously proposed by Dong.

**Key words:** longitudinal load; structural stress; fatigue life; T welded joints

**Analysis on temperature and stress of SiC/316L coating by ultrasonic-assisted laser cladding**  
LI Deying, ZHANG Jian, ZHAO Longzh, DENG Zhicheng (Institute of Laser Manufacture Technology for Advanced Materials, School of Materials, East China Jiaotong University, Nanchang 330013, China) . pp 35 – 39

**Abstract:** The finite element model of SiC/316 L composite coating was established. The boundary conditions with ultrasonic vibration was made approximation by the method of combining thermal effects conversion with dynamic boundary conditions imposed. The temperature distribution and residual stress of SiC/316 L composite coating by ultrasonic-assisted laser cladding were discussed. The influence of ultrasonic amplitude and scanning speed on the temperature field and stress field were investigated. The results show that the surface temperature of coating is increased with the decrease of ultrasonic amplitude and scanning speed. The residual stress of coating is reduced with ultrasonic vibration. With the increase of ultrasonic amplitude and scanning speed, the residual stress reduces firstly and increases afterward. The experiment of ultrasonic cladding is prepared by the optimized technological parameters. The test results show that the microstructure of coating are refined and uniform with ultrasonic vibration, which is conducive to reduce the residual stress of coating.

**Key words:** ultrasonic vibration; laser cladding; composite coating; temperature field; stress field

**Effect of refill time on fracture feature of refill friction stir spot welding**  
JI Shude¹, WANG Yue¹, MA Lin², CHAI Peng², GAO Shuangsheng (1. Faculty of Aerospace Engineering, Shenyang Aerospace University, Shenyang 110136, China; 2. School of Mechanical Engineering & Automation, Beihang University, Beijing 100191, China) . pp 40 – 43

**Abstract:** In order to investigate the effect of refill time on fracture mode and fracture mechanism on refill friction stir spot welding (RFSSW), the LY12 aluminum alloy plates with
Double pulse welding method for twin-wire pulsed MIG welding  WU Kaiyuan1,2, HE Zuwei1,2, LIANG Zhuyong1,2, HUANG Xi1(1. School of Mechanical & Automotive Engineering, South China University of Technology, Guangzhou 510640, China; 2. Engineering Research Center for Special Welding Technology and Equipment of Guangdong Province, South China University of Technology, Guangdong 510460, China). pp 53 – 57

Abstract: To improve the forming quality of twin-wire pulsed MIG welding, double pulse welding method for twin-wire pulsed MIG welding was proposed. A DSP based double pulse digital anti-phase synergic control system was constructed, with which surface welding experiments of single pulse and double pulse twin-wire pulsed MIG welding were conducted. Experimental results indicated that the process of double pulse welding was stably achieved on the constructed twin-wire MIG welding system, and the weld seam formation was decent. By using metallographic analysis of the weld seams of single and double pulse test, it could be concluded that double pulse features a great stirring effect on the welding pool, and that as pillar dendrite crystal vanished, the crystal grain size of welding seam of double pulsed welding was smaller than that of single pulsed welding, demonstrating that the application of double pulse to twin-wire pulsed MIG welding brought about notable optimization.

Key words: twin-wire pulsed MIG welding; double pulse; digital control; metallography of welding seam

High precision prediction method of residual stress and welding distortion of aluminum alloy sheet LIANG Wei, GUO Kefeng, GONG Yi, BIAN Gongwen (College of Mechatronics &Vehicle Engineering, Chongqing Jiaotong University, Chongqing 400074, China). pp 58 – 62

Abstract: In this paper, a new material model with considering softening phenomena in aluminum alloy welded joint was developed to accurately calculate welding residual stress and deformation. In the current study, the welding residual stress and distortion in a 6061 aluminum alloy head-on joint performed by TIG welding process was simulated by using the developed computational approach. Meanwhile, the out-of-plane deformations were measured by experiment, and the measurements were used to verify the numerical results. The numerical results show that softening effect has a significant influence on longitudinal residual stress, which has a limited influence on transverse residual stress. It seems that the softening effect could only influence on welding deformation.

Key words: softening effect; aluminum alloy; residual stress; welding deformation; numerical simulation

Influence of separate area scanning on coupled thermo-mechanical field of laser repairing of titanium alloy YANG Guang, ZHOU Jiapeng, QIN Lanyun, WANG Wei (Key Laboratory of Fundamental Science for National Defence of Aeronautical Digital Manufacturing Process, Shenyang Aerospace University, Shenyang 110136, China). pp 63 – 68

Abstract: In order to control the residual stress in the process of laser deposition repair and reduce the deformation of the substrate, a laser deposition parts thermal coupling field numerical simulation in the repair surface was established on the ANSYS parametric design programming language. Thermal cycle characteristics, distribution rule of temperature field and residual
stress field was analyzed under sequential scan and subarea scan. The results showed that the thermal cycle of nodes was similar under different scanning patterns. And substrate heat accumulation decreased greatly by subarea scan, at the same time the temperature distribution is relatively uniform so as to improve the stress concentration in the substrate and reduce residual stress. In order to verify the result, laser deposition temperature field and residual stress were measured by infrared thermometer and indentation strain gauge, and the substrate material deformation curve was plotted. The results showed that numerical simulations was in good agreement with the experimental results.

**Key words:** separate area scanning; thermo-mechanical field; laser repairing; numerical simulation

**Corrosion behavior of TIG welded joints of 316L stainless steel in H2S solutions**

LU Xiang1, FENG Xingguo2, LU Sheng3, WANG Zexin1, ZHENG Chuanbo1 (1. School of Materials Science and Engineering, Jiangsu University of Science and Technology, Zhenjiang 212003, China; 2. College of Harbour, Coastal and Offshore Engineering, Hohai University, Nanjing 210098, China) . pp 69 – 73

**Abstract:** 316 L stainless steel welded joints was prepared by tungsten-arc inert gas (TIG) welding. The corrosion behavior of the TIG welded joints of 316 L stainless steel in different concentrations of H2S solutions are studied by polarization curves, electrochemical impedance spectroscopy (EIS), Mott-Schottky plots, and immersion corrosion experiments. Polarization curves and EIS results show that the corrosion current densities of the joints significantly increased as the concentration of H2S solutions increasing, while the corrosion potential decreased. Additionally, for the samples in the same concentration of H2S solutions, the 316 L base material shows the lowest corrosion current densities, next is the heat-affected zone, the welded zone presents the highest corrosion current densities. Mott-Schottky plots show that the passive films appear a p-n heterojunction, and the donor and acceptor densities reach 1 022 cm⁻³, showing a highly defective character of the passive film. The donor and acceptor densities increase with increasing H2S concentrations. The decreased passivity and the increased doping density affect the protectiveness of the passive film toward corrosion.

**Key words:** stainless steel; TIG; H2S solution; corrosion

**Effect of ultrasonic power on microstructure and properties of Fe-Cr-V-C coating by laser cladding**

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**Abstract:** The coating with high strength, high hardness and high wear resistance were prepared by laser cladding. The effect of ultrasonic power on the microstructure and properties was investigated through optical microscopy, SEM, XRD and MSL-23 wet sand rubber wheel tester. Meanwhile, the grain size was calculated by the Image-Pro Plus software. The results show the effect of ultrasonic power on microstructure and properties of the coating is very obvious. With the increasing of ultrasonic power, the grain size reduces from 87µm to 6µm, which has a strong correlation with obvious cavitation effect and acoustic stream. The hardness and relative wear resistance increase at first, then decrease. When the ultrasonic power is 1 000 W, the grain size is 6 µm. The hardness is very high, the value is 62 HRC. The relative wear resistance is very high, which is about 50 times than that of substrate.

**Key words:** ultrasonic power; laser cladding; microstructure; wear resistance

**Microstructure characterization of duplex stainless steel multi-pass welded joint**

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**Abstract:** Duplex stainless steel (DSS) welded joint was fabricated by tungsten arc welding method. Equilibrium phase transformation processes of base material and weld were calculated by thermodynamic method. Microstructures in different zones of DSS welded joint were characterized by optical microscope, scanning electron microscope, energy dispersive spectroscopy, and transmission electron microscopy. The results showed that the Ni addition in the weld significantly promoted austenite (γ) formation and prevented Cr₂N precipitation. The primary austenite (γ₁) in the weld and the heat affected zone (HAZ) mainly consisted of grain boundary austenite, Widmanstatten austenite, and intragranular austenite. There were obvious composition differences in the different types of austenite. Furthermore, there were two types of secondary austenite (γ₂) in both the weld and the HAZ; intragranular and intergranular γ₂. The γ₂ were easy to precipitate within the ferrite (δ) and in the/γ₁ interface where enriched in Ni and N element while depleted in Cr and Mo element. In the HAZ, the Cr₂N were mainly precipitated within the grain, in the/γ₂ interface, and in the boundary.

**Key words:** duplex stainless steel; multi-pass welding; microstructure; secondary austenite

**Mechanism of activated carbon layer on SiO₂/SiO composite to assist brazing alloy wetting**

LIN Jinghuang, BA Jin, QI Junlei, FENG Jicai (State Key Laboratory of Advanced Welding and Joining, Harbin Institute of Technology, Harbin 150001, China) . pp 83 – 86

**Abstract:** A new method was proposed to preparation of activated carbon layer on SiO₂/SiO₂ composite to assist brazing alloy wetting, in order to solve the problems that poor wettability of brazing alloy on SiO₂/SiO and poor performance of joints. PECVD was occupied to preparation of extremely thin activated carbon layer on the surface of SiO₂/SiO₂ composite to assist active brazing alloy spreading and wetting. Analysis showed that the method can prepare activated carbon layer on the surface of SiO₂/SiO at the temperature of 400 °C and holding time for 15 min, and the surface morphology of composite showed no obvious changes. Wetting results showed that introducing activated carbon layer can significantly improve the wettability of Ag-Cu-Ti brazing alloy on the surface of SiO₂/SiO₂ composite when the wetting angle dropped from 131° to 27° at the temperature of 860 °C and holding time for 10 min. Activate carbon layer can promote the wettability of active brazing alloy, because carbon showed good affinity with active elements to activate the surface
state of SiO$_2$/SiO$_3$ composite.

**Key words:** SiO$_2$/SiO$_3$ composite; activated carbon layer; preparation in situ at low temperature; wettability

**Analysis on microstructure and properties of under-matching welding joint of high strength steel 10Ni5CrMoV**

LI Dayong, YANG Dongqing, WANG Ping, ZHANG Guangjun
(State Key Laboratory of Advanced Welding and Joining, Harbin Institute of Technology, Harbin 150001, China).

Abstract: In order to solve the inevitable cold crack problem in 10Ni5CrMoV high strength steel thick plate welding under the condition of large constraint degree, the high-chromium-nickel austenitic stainless steel welding wire with low-match strength was developed in this paper. The microstructure and properties of the welded joint were analyzed. The results showed that the formation of the welded joint was good without crack defects. The welding metal was mainly composed of dendritic austenite and a small amount of granular precipitates. The tensile strength of the joint was 800 MPa and the sample after bending test was not fractured. The impact toughness AKV (-80 °C) was greater than 90 J, which meets the technical requirements.

**Key words:** 10Ni5CrMoV; austenitic stainless welding wire; low strength match; microstructure and properties

**Formation and characterization of Al-Al explosive welding interfaces**

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Abstract: In this paper, a series of Al-Al quasi-symmetric explosive welding experiments were carried out and then the samples with variation charge ratio were obtained. Furthermore, the processes of Al-Al oblique collision were simulated based on smooth particle hydrodynamic method (SPH) in AutoDyn, and it was found that the simulation results were in agreement with the experiments. It is can be conclude that, first the wave length and amplitude increased with progressive increasing of charge ratio, as well as the thickness of re-entrant jet. In addition, the interfaces became more continuous. Second, the influence of charge ratio of re-entrant jet velocity was rare. Third, the shear stress of base plate enhanced with the increase of re-entrant jet, which leads to the interface gradual changing from straightness to wave. The variation laws of Al-Al explosive welding interfaces with charge ratio and the numerical method used in this paper will be beneficial for correlation research.

**Key words:** explosive welding; charge ratio; SPH; interface wave; shear deformation

**Microstructure of electron beam welded thick-wall Ti80 joint**

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Abstract: Experiments of electron beam welding was carried out for 56 mm thick Ti80 titanium alloy. Then the microstructure of the joint was studied, the results show that micro-structure of weld metal is composed of needle martensite $\alpha$ phase and $\beta$ phase, and it’s size increased by cooling speed’s rising. The microstructure of HAZ can be divided into three regions. The microstructure of HAZ near fusion zone (1 zone) was consisted of primary $\alpha$ phase, needle $\alpha$ phase, needle martensite $\alpha$' and transferred $\beta$ containing acicular $\alpha$; The microstructure of HAZ near the base metal (2 zone) was consisted of primary $\alpha$ phase, secondary $\alpha$ phase and $\beta$ phase.

**Key words:** Ti80 alloy; heavy plate; electron beam welding; fine microstructure

**Analysis of impact toughness variation for flat position multi-pass weld joint**

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Abstract: A multi-pass weld metal in flat position was studied, which was welded by a flux cored wire used in X70 pipeline. Analysis included observation of the fracture surfaces to determine initiation location (optical and scanning electron microscopy) and metallographic examination of the weld microstructures. It was found that the position of impact specimen is different, which will cause different impact energy; the proportion of the columnar crystal or coarse crystal area, which was near the position of impact specimen notch root, was a main reason for the impact toughness variation but is not the main reason of low values. The weld defects and coarse grain were the main reason for the variation and low values of impact toughness. When the impact energy is 54.2 J, the impact sample was cleavage fracture. Crack source were welding defects such as inclusions, the defects of incomplete fusion and so on, and the nearer the position of these defects to the notch, the smaller the impact energy.

**Key words:** multi-pass weld metal; impact toughness; variation

**Analysis of joint fracture of magnesium alloy and galvanized steel by resistance spot welding**

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Abstract: 2.0 mm thick AZ31B magnesium alloy and 1.0 mm thick SPHC galvanized steel were welded by kDWJ-17 three-phase secondary rectification resistance welding machine. The fracture feature of the joint of magnesium alloy and galvanized steel by resistance spot welding was studied by the optical microscopy observation, scanning electron microscopy (SEM) and atomic binding energy. The results show that joint fracture presented in the form of junction surface fracture and button fracture. Tensile shear of button fracture was better than junction surface rupture. Button fracture was main of ductile fracture surface, mixed little brittle fracture surface. Button fracture occurred when Fe-Al compound is mainly distributed in the nugget. Grain grewed coarse near the fusion line and Fe-Al binding energy is strong made the fracture location were in the fusion line. Joint surface fracture occurred when Mg-Zn compound was main in the nugget. Binding energy of Mg-Zn compound is weak, which were easily pulled off.

**Key words:** magnesium alloy; galvanized steel; resistance spot welding; joint fracture
Thermodynamic prediction for phases of ceramic coatings in Ti-Si-C system by argon arc deposition  YAN Wenging1, ZHANG Jianqiang2, LIU Sheng1 (1. Key Laboratory for Ferrous Metallurgy and Resources Utilization of Ministry of Education, Wuhan University of Science and Technology, Wuhan 430081, China; 2. School of Power and Mechanical Engineering, Wuhan University, Wuhan 430072, China) . pp 108 – 111

Abstract: Based on the thermodynamic principle, the relation between reaction enthalpy, Gibbs energy and temperature were deduced. Using phase graphs of Ti-Si-C, 12 reactions occurring possibly during TIG arc deposition on the titanium alloys were analyzed by thermodynamics. The thermodynamic calculation results showed that titanium can react with SiC, Si and C to forming ceramic phases of TiC and Ti5Si3 and intermetallic compound of Ti5Si3 and Ti3Si. The theoretical analysis results showed that the phases of deposition layers can be predicted using thermodynamic analysis by changing the compositions of different raw materials on the TIG arc conditions. The experiment results showed that the prediction results were corresponding well with experiments results.

Key words: tungsten argon arc deposition; ceramic deposition layers; phase; thermodynamic prediction

Process optimization of high strength aluminum alloy TIG welding under vibration  SU Yunhai, AI Xingyu, ZHANG Guiqing, LIU Jiguo (School of Material Science and Engineering, Shenyang University of Technology, Shenyang 110870, China). pp 112 – 115

Abstract: Al-Cu-Mg high strength aluminum alloy was welded by semi-automatic TIG welding using Al-Si-based wire. During welding process, the mechanical vibration was applied. In order to optimize the process parameters, the orthogonal test was used. The tensile properties, hardness, microstructre and phase analysis were studied for different parameters of high strength aluminum alloy welded joint to research the interaction and mechanism of vibration. The results show that the optimum matching parameters are as follow, welding current I = 110 A, the vibration amplitude D = 0.05 mm, vibration frequency f = 50 Hz. The performance at this time is that tensile strength Rm = 289.68 MPa, elongation δ = 4.95%, and the average hardness of the weld 108.0 HV. Vibration parameters can promote the formation of fine crystal axes, inhibit the production of porous defects. Suitable parameters vibration can refine the microstructure of the weld zone, inhibit the production of porous defects. The microstructure of the weld is mainly composed of fine equiaxed dendrite and cellular dendrite. So the comprehensive mechanical properties of welded joints will be improved.

Key words: high strength aluminum; microstructure; mechanical properties; strengthening mechanism

Optimization of narrow groove plasma-MAG hybrid welding process parameters  WU Xiayang1, ZHANG Zhiyi1, QI Weichuang1, TIAN Renyong1, SHI Chunyan1 (1. CRRC Qingdao Sifang Locomotive and Rolling Stock Co., Ltd., Qingdao 266111, China; 2. Dalian Jiaotong University, Dalian 116028, China). pp 116 – 119

Abstract: The side-axis plasma-MAG hybrid welding process with V-style 30° narrow angles was conducted to solve the problems of the MAG welding deformation and the back shaping of the root weld bead for bogie frame. In this paper, the butt plate of SMA90BW weathering steel was regarded as the research object. A mathematical relationship model was established between the plasma current, MAG current, welding speed, plasma gas flow which affect the weld penetration and the penetration, back reinforcement of root pass based on response surface method, and by means of this model, the influence of the plasma-MAG hybrid welding process parameters to the weld penetration capability was analyzed, so as to get the suitable hybrid welding process parameters. Compared with the ordinary MAG welding process, the narrow-groove plasma-MAG welding process is able to ensure the full penetration of weld root and to reduce welding deformation of the joint effectively.

Key words: plasma-MAG welding technology; response surface method; parameter optimization; welding deformation

Influence of heat input on toughness in coarse grain zone of QT900 coated tubing butt welding  HOU Chunfeng, SHI Kai, LI Xiao, LIANG Wei (Material Science and Engineering Institute, Xi’an Shiyou University, Xi’an 710065, China). pp 120 – 124

Abstract: In this paper, thermal simulation technology, microstructure analysis and fracture surface topography analysis techniques are used to study the influence of heat input on the impact toughness and embrittlement mechanism of coarse grain zone in butt weld of QT900 coated tube. The result shows that fine needle lathe bainite can be obtained under 5 kJ/cm heat input, it improves impact energy and provides good impact toughness to coarse grain zone; with the heat input increased from 5 kJ/cm to 10 kJ/cm, grain size increases in coarse grain zone, bainitic ferrite laths become wider, and the grain boundary allotriomorphs will nucleate and grow along the original austenite grain boundaries, which decrease toughness in coarse grain zone.

Key words: coated tubing; welding heat input; CGHAZ; impact toughness

Effect of solid-state phase transformation on welding residual stress of 10Ni5CrMo steel  WANG Ping1,2, LIU Yong1, LI Dayong1, FANG Hongyan1 (1. State Key Laboratory of Advanced Welding and Joining, Harbin Institute of Technology, Harbin 150001, China; 2. China Shipbuilding Industry 431 Shipyard, Harriadao 125000, China). pp 125 – 128

Abstract: 10Ni5CrMo steel is a high strength low alloy steel (HSLA), its solid-state phase transformation effects cannot be ignored in welding mechanical analysis. In this study, welding numerical simulation is conducted with consideration of solid-state phase transformation effects including volumetric change and hysteresis of yield strength. The results show that longitudinal tensile stress become much lower in phase transformation zone, but it maintains high stress level in adjacent areas. Nevertheless, the distribution of transverse stress is changed a lot, with a similar peak value, approximately 25% of yield strength at room temperature. And it is approved that both longitudinal and transverse residual stress are in good agreement with experimental measurements.

Key words: solid-state phase transformation effects; 10Ni5CrMo steel; welding residual stress; numerical simulation